Thomas Edgar Sikes,

Greensboro, N.C.

June 30, 1927

A TEXTBOOK OF EXODONTIA

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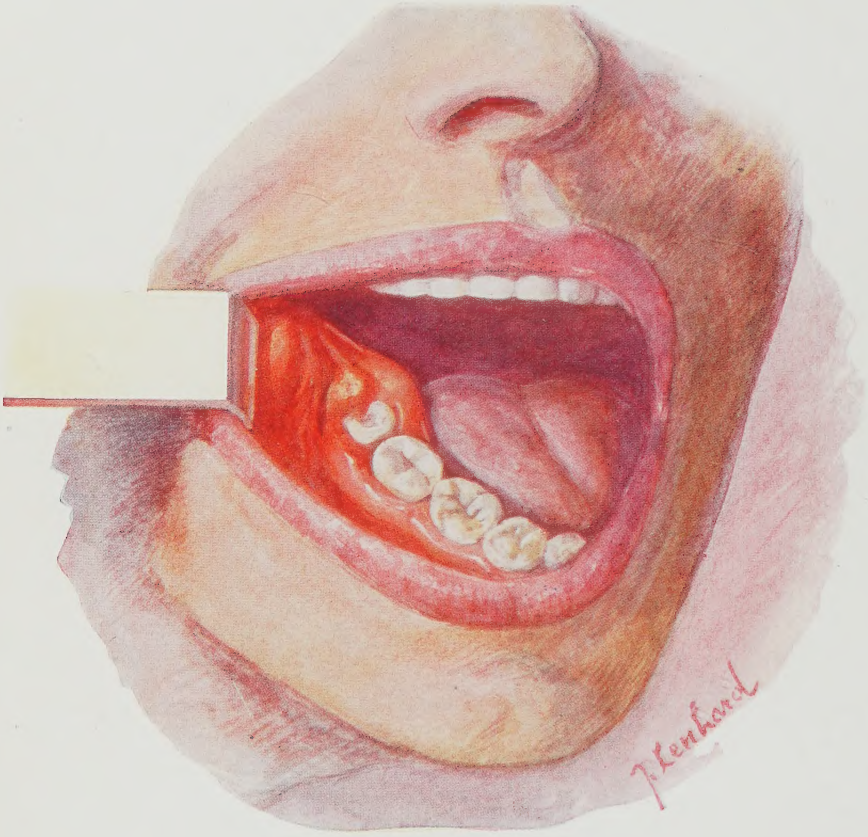

PLATE I.

Typical pericoronitis of mandibular third molar.

A TEXTBOOK

OF

EXODONTIA

EXODONTIA, ORAL SURGERY AND ANESTHESIA

BY

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WITH 329 ILLUSTRATIONS

ST. LOUIS

THE C. V. MOSBY COMPANY

1927

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Printed in U. S. A.

Press of
The C. V. Mosby Company
St. Louis

TO MY WIFE
SYLVIA H. WINTER

PREFACE

In the fulfillment of many promises made from time to time to my students and other friends, I have prepared the following pages, embodying in the main, the results of my observations and experiences during a somewhat extended practice in that branch of dentistry to which it specifically relates.

In the hope that the volume will be a useful textbook in assisting the student to prepare for the responsible duties of the profession, and that it will serve as a reliable guide to the intelligent practitioner, it is herewith offered to the attention of those who are about to enter the field of their labors and of those who, though more familiar with the practical features of the matters presented, may desire to acquaint themselves more fully with the latest methods of practice.

I wish to express my appreciation to Dr. Holmes Condict Jackson, Dean of the New York University College of Dentistry, and to Dr. John Bethune Stein, also to my associates Dr. David Coddington Baker, Dr. Michael M. Moss, Dr. I. Salman, Dr. E. Lembeck, Dr. Frederick Whiting, Dr. H. M. Seldin, Dr. A. L. Greenfield, Dr. Henry Musterman, Dr. S. Hess, and Dr. Gaston Labat, and especially to Dr. Louis V. Hayes for his untiring efforts and assistance in the preparation of this work.

That the work may prove a source of benefit to his fellow practitioners and a measure of helpfulness to the public is the highest hope of

LEO WINTER.

New York City.

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EXODONTIA

CHAPTER I

GENERAL ANESTHESIA

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Definitions

Local Anesthesia: Loss of sensation in a circumscribed area produced by the application of a chemical or physical agent.

General Anesthesia (anesthesia, narcosis), *Unconsciousness* with loss of pain sense: A condition in which there is a paralysis of all vital functions of the body except the centers of respiration and circulation; a complete paralysis of the nervous mechanism presiding over cerebration, sensation, and motion, excepting the centers of respiration and circulation.

General Analgesia: Loss of sensation of pain in the entire body, consciousness being intact.

Shock: Prostration of body functions, indicated by pallor, shallow respiration, pulselessness, dilated pupil, clammy perspiration, and extreme relaxation of the muscles.

Cyanosis: A livid blue color of the skin.

Asphyxia: Suffocation.

Acapnia: A condition of diminished carbon dioxide in the blood.

Hyperpnea: Excessive respiration.

Apnea: Suspension of respiration.

HISTORY OF ANESTHESIA

From the earliest times man has sought to assuage grief and pain by some means of dulling consciousness. Both the Bible and the Talmud contain references to the ancient practice

of inducing sleep by artificial measures. Moses never would have written that "God caused a deep sleep to fall upon Adam" had not his people known something of general anesthesia. An Egyptian carving, dated 2500 B.C., has lately been discovered, which illustrated how anesthesia may be produced by means of pressure. Chinese literature also has references to the use of Mandragora and other herbs for dulling pain. The first record of "local analgesia" was found upon a clay tablet excavated at

—*From Holmes and Kittermann*

Fig. 1.—Egyptian carvings (about 2500 B.C.) illustrating how anesthesia may be produced by means of pressure.

Nippur near Babylon, the date of which is approximately 2250 B.C. In the Babylonian tongue, the official language of diplomacy in that age, is inscribed a prescription for abolishing the pain arising from an aching tooth. (Hammurabi, King of Babylon at that time, was a contemporary of Abraham.) The tablet states that the treatment consists in filling the painful cavity of the tooth with a cement prepared by mixing powdered henbane seed with gum mastic. In Egypt, the suet of the crocodile, locally applied, was believed to relieve pain. In an early Cymric manuscript, which was probably written about the end of the fifteenth century, are the following directions: "How to

extract a tooth without pain: Take some lizards and those nasty beetles found in ferns. Calcine them in an iron pot, and make a powder thereof. Wet the forefinger of the right hand and insert it in the powder, and apply it to the tooth frequently, refraining from spitting it off, when the tooth will fall away without pain. It is proved."

During the classic age of Grecian literature, Homer tells us that Helen of Troy put a drug into the wine to "lull pain and anger, and bring forgetfulness of every sorrow." Five hundred years later, Herodotus wrote of the Scythians inhaling fumes of hemp which produced an exalted mental state followed by sleep. Later on, other Greek historians, Dioscorides and Galen, refer in unmistakable language to like practices. The chronicles of ancient Rome furnish similar evidence. Pliny describes the employment of Mandragora to relieve the sufferings of those condemned to crucifixion. Unquestionably, certain practices and drugs that would produce anesthesia have been lost to the world following the many disastrous wars that from time to time have blotted out civilization. (The art of embalming as practiced by the Egyptians is extinct today.)

Shakespeare refers to the state of anesthesia as it is now known, but this was probably poetic license. He makes Cornelius prescribe a drug which

> " Will stupefy and dull the sense awhile: but there is
> No danger in what show of death it makes,
> More than the locking up the spirits a time,
> To be more fresh, reviving."

The beginning of modern, scientific anesthesia was foreshadowed by the discovery of the synthesis and properties of ether, in about the year 1540 by Valerius Cordus, and by Priestly's discovery of oxygen and nitrous oxide in 1772. Ethyl chloride was first obtained in alcoholic solution by Basil Valentine. Glauber referred to it in 1648. In 1800, Sir Humphrey Davy stated that "Since nitrous oxide seems capable of destroying physical pain, it may be used in surgical operations where there is no great effusion of blood." (As a matter of fact, it is now used whenever "great effusion of blood" or shock is expected.)

Sulphuric ether was used in 1805 by Warren (Boston) on patients suffering with phthisis, and in 1806, in attacks of

asthma. In 1818, a paragraph appeared in *The Quarterly Journal of Science and Arts* that is usually attributed to Faraday, in which it is stated that "when the vapor of ether is mixed with common air and inhaled it produces effects very similar to those occasioned by nitrous oxide." The use of ether for other purposes than anesthesia is an interesting study in evolution, but it will not be touched upon here.

The development of surgical anesthesia was a tragic story for those immediately concerned. Henry Hill Hickman at twenty years of age became a member of the Royal College of Surgeons. He was a country practitioner in the little town of Ludlow, England, and made the first successful experiments with anesthetics upon lower animals between the years 1820 and 1828. His British colleagues were unimpressed by his efforts to relieve pain, and French surgeons were no more sympathetic in their attitude. Hickman practically sacrificed his career and his life in attempts to gain recognition of his discovery for relieving pain during surgical operations, dying at the early age of twenty-nine.

Chloroform was independently discovered in 1831 by Guthrie Souberan, and Liebig.

Later, both ether and nitrous oxide were used, especially by medical students, for inhalation to the point of intoxication, or stage of excitement.

It remained for Dr. Crawford W. Long, a graduate of the University of Pennsylvania and a country practitioner of Georgia, to be the first man to employ ether intelligently for surgical operations. The bill for one operation is still in existence, showing the very low cost of surgical operations and living at that time. It is as follows:

James Venable,
to Dr. C. W. Long, Dr.

1842		
Jan. 28,	Sulphuric ether	$ .25
Mch. 30,	Sulphuric ether and exsecting tumor,	2.00
May 13,	Sul. ether,	.25
June 6,	Exsecting tumor,	2.00
		$4.50

Long continued to use ether in his practice from time to time, but he did not publish his discovery nor make any claim for priority until after the successful demonstration by Morton, and so he is necessarily deprived of the larger honor which would have been his had he been less modest. Long was not embittered, as were others who advanced their claims for priority, and he is the only one of the group under consideration who died a peaceful death, at the age of sixty-two.

In 1844, Horace Wells, a dentist of Hartford, Conn., rediscovered the anesthetic qualities of nitrous oxide and used this gas for the painless extraction of teeth. In 1845, he attempted a public demonstration before the Harvard Medical College which proved a disastrous failure. Being a sensitive man, he was overwhelmed with mortification and felt himself disgraced. He continued, however, to use the gas in his private practice. Four years after his discovery, his reason having given way early in 1848, he died by his own hand.

William T. G. Morton, a successful dentist of Boston, and a former pupil of Wells, discovered the anesthetic properties of ether, as far as we know, entirely independent of Long's discovery. The ether was used at the suggestion of Charles T. Jackson, a chemist of Boston. Morton was unquestionably the first man to give a successful public demonstration of surgical anesthesia. This occurred on October 16, 1846, in the Massachusetts General Hospital in the presence of the medical and surgical staffs. The circumstances were very dramatic.

Morton came into the amphitheatre late, having been delayed by waiting for the completion of a new inhaler. Just a few minutes before, Dr. Warren had remarked: "As Dr. Morton has not arrived, I presume he is otherwise engaged," apparently wishing to convey the idea that Dr. Morton was not likely to appear. As he was about to proceed with his operation, Morton entered. Amidst that sea of faces he saw not one which was sympathetic. Blank incredulity or, at the best, curiosity alone was to be seen. Warren, turning to him, remarked: "Well, sir, your patient is ready." Adjusting his apparatus, Morton calmly administered the anesthetic and, turning to Dr. Warren, said: "Dr. Warren, *your* patient is ready." The silence of the tomb reigned in the large amphitheatre while Dr. Warren made his

first incision through the skin and dissected out a large tumor while the patient made no sign nor moved a muscle of his body. When the operation was completed, Dr. Warren turned to the audience and said slowly and emphatically: "Gentlemen, this is no humbug," and Bigelow remarked: "I have seen something today that will go round the world."

A little over a month later, Oliver Wendell Holmes wrote a letter to Dr. Morton, dated November 21, 1845, suggesting that the state produced by the new anesthetic should be called "anesthesia," a term which "will be repeated by the tongues of every civilized race of mankind." In July, 1868, Morton left his home for New York to reply to an article that had recently appeared advocating Jackson's* claim as the discoverer of ether anesthesia. The agitation and extremely hot weather then prevailing affected him to such an extent that in driving through Central Park he lost consciousness and died while being taken to St. Luke's Hospital. Morton is the only physician holding a place in the Hall of Fame today.

On March 8, 1847, Fluorens, a Frenchman, pointed out the anesthetic qualities of chloroform and ethyl chloride. During the same year, Sir James Y. Simpson consulted Waldie, a chemist of Liverpool, who suggested the use of chloroform instead of ether, for obstetrics. On November 4, 1847, Simpson discovered the anesthetic properties of chloroform and made known the fact in a paper read on November 10 of the same year. With the introduction of ether in 1846, and the death of Horace Wells in 1848, nitrous oxide was not thought of again until Colton, of New York, revived its use in 1863. In 1867, Colton was able to give a record of twenty thousand successful cases. Since that time it has occupied the foremost place as an anesthetic in modern dentistry. In 1868, Andrews of Chicago, published accounts of a nonasphyxial form of anesthesia produced by using oxygen with nitrous oxide. At the present time this last combination has been improved upon by the addition of ethylene; this last combination also has an active competitor in novocaine, an anes-

*Charles T. Jackson, chemist, mineralogist, and geologist, supplied essential knowledge and suggestions in the development of both the electric telegraph—made workable by Morse—and etherization—made practical by Morton. During his life-time he never received recognition for these contributions to science that was justly his, especially from Morse and Morton. Constant worry and anxiety caused a mental derangement, from which he never recovered.

thetic which is used successfully in blocking the nerve supply to any part of the body.

Local, spinal, paravertebral, and similar forms of analgesia through the physiologic action of special drugs, were made possible by Alexander Wood, who, in 1853, introduced the *hypodermic syringe.*

In 1859, Nieman discovered the alkaloid of cocoa leaves, cocaine. Three years later, 1862, Schraff discovered the local analgesic properties of cocaine when placed upon the tongue. Koller, in 1884, demonstrated its analgesic properties when used in the eye. Other early clinical demonstrations were made by Halsted, 1884, and by Corning, 1885. The addition of adrenalin to cocaine, producing a local ischemia and thus retarding absorption, is a valuable aid against poisoning and was brought out by Elsberg, Barker, and Braun.

Intravenous anesthesia was first attempted by Ore, of Lyons, France, in 1872. Unfortunately, he used chloral hydrate in solution, which was found to be toxic, and the method was discredited for the time being. Professor Burkhardt, of Wurzburg, was the first to use ether in a 6 per cent water solution intravenously. This method, while safe and efficient, requires a perfected technic and consumes too much of the surgeon's time. Hence it is but little used at the present time.

Investigations by Rosemann and Grehant in 1895, showed that if acetylene (C_2H_2) was mixed with air and inspired, anesthesia resulted in laboratory animals.

Spinal analgesia was first placed upon a practical basis by Bier, of Kiel, in 1899. This method consists of the injection of a local anesthetic into the sheath of the lumbar cord. Bier used 2 c.c. of a 1 per cent solution of cocaine.

Novocaine, discovered by Einhorn, was first clinically tested by Braun, in 1905, and it is now recognized as the best and safest substance for the production of local analgesia.

Anociation was developed by George W. Crile and his associates in Cleveland, Ohio. It consists of a combination of general anesthesia and local analgesia.

Paravertebral analgesia was first suggested by Sellheim, 1906, and later developed principally by Laewen in 1911, and Kappis, in 1912.

Parasacral analgesia was first suggested by Braun. The method is safe and no mishaps have been reported.

Paravertebral and splanchnic analgesia represent the greatest development in the technic of nerve blocking. Nerve blocking is especially important to dentists.

Colonic anesthesia is of special interest to dentists for prolonged operations. Pirogoff, in 1847, was the first to mention this method, but at that time the technic was imperfect and dangerous, and was discontinued after a short trial. Cunningham of Boston (1903-05) and Sutton at Roosevelt Hospital (1910) improved upon the former technic, but the method was still dangerous. Gwathmey (1913) improved upon all previous methods by combining oil with the ether and placing a sufficient quantity of the mixture in the rectum at one time for a complete operation.

Arno B. Luckhardt, M.D., of Chicago, and his associates discovered and reported the analgesic qualities of ethylene (first prepared by one Becker, previous to 1779) on April 27, 1923. Brown, of Canada, at about the same time and independently announced the properties of the same gas. It occupies a position between nitrous oxide and ether.

CHLOROFORM—$CHCl_3$ (Trichlormethane)

Properties.—Chloroform is a colorless limpid fluid, having a sweet but burning taste and an agreeable "ethereal" odor. It is not combustible. Though only slightly soluble in water, it is miscible in all proportions in alcohol and ether. It has a density of 1.49887 at 15/4° and boils at plus 61.2° C.,—the heaviest specific gravity of all anesthetics. Anesthetic chloroform contains 0.25 to 1.00 per cent ethyl alcohol as a preservative.

Uses.—It is used as an anesthetic, antispasmodic, counterirritant, and antiseptic in dentistry; as a solvent, it dissolves fats, resins, sulphur, phosphorus, iodine, and alkaloids.

How Made.—From alcohol by treatment with chloride of lime.

Containers for chloroform are bottles of high grade anactinic *glass,* containing about the quantity sufficient for one narcosis, i. e., *one ounce bottles.* If there is a residue, it should be thrown away, for chloroform decomposes rapidly upon exposure to air.

Physiologic Considerations

Respiratory System.—*The effects* are secondary to the effects upon the circulation, low arterial tension being a factor. A concentrated *vapor* causes a reflex closure of the larynx, with asphyxiation symptoms. Chloroform diminishes the excitability of the respiratory center to the carbon dioxide stimulus. With deep and rapid respiration, there is a marked fall in the carbon dioxide content of the blood. Diminution in oxygen content of the blood during narcosis is the effect of the action of the drug on the red blood corpuscles,—a direct action upon the nervous mechanism of respiration.

Effects upon the Circulatory System.—First, deoxidation occurs by diminishing the supply of air to the alveoli of the lungs; secondly, a physicochemical action of this diminished deoxidized blood supply takes place upon the cerebral centers. As *a direct cardiac depressant* it paralyzes the neuromuscular mechanism of the blood vessels, and this partly accounts for the fall in blood pressure. A *dilatation* of the entire cardiovascular system follows the inhalation of $ChCl_3$. There is only a *narrow* margin between a therapeutic and a toxic dose. The *brain* contains three times more chloroform than an equal weight of blood. Cardio-inhibitory effects are common with 2 per cent or more chloroform vapor.

Effects upon the Nervous System.—A progressive paralysis of the central nervous system occurs as follows:

1. The higher cerebral centers, involving intellectual faculties.
2. The lower cerebral centers, involving sensation and motion.
3. The spinal cord, involving reflex action.
4. The medullary centers, involving vital function.

Effects upon the Muscular System.—(1) Muscular spasm, tonic or clonic, is greater with the more muscular patients; (2) muscular relaxation follows.

Effects upon the Glandular System.—Mucous, salivary, and sweat glands hypersecrete during light chloroform anesthesia. Chloroform has a special affinity for *fat*, and for liver, kidney, spleen, and nerve tissue. The liver of the fetus is even more affected than is that of the mother.

A light anesthesia—urine is increased.

A deep anesthesia—urine is diminished; it may be suppressed.

After-effect—a great increase. It affects the cells of the liver, interfering with metabolism of fat, liberating fatty acids, and causing an acid intoxication. It checks adrenal functions.

Cause of Death is oxygen starvation (Gill). Chloroform is a protoplasmic poison and a marked circulatory depressant.

Stages of Anesthesia (Arbitrarily divided into four)

First Stage.—Light vapor (2 per cent or less of $ChCl_3$). No subjective phenomena are noted.

If strong vapor is used breath-holding, coughing, retching, vomiting, and cyanosis, may occur with increase of the heart action and rise of blood pressure. If an operation is attempted at this time, death may result from reflex inhibition.

Second Stage, or Stage of Excitement.—Respiration becomes irregular, the pulse rapid, and the muscles, particularly those of the jaw and neck, show clonic and tonic spasms, indicating a need of air. Pupils are widely dilated, lid reflex is active, and the eyeballs are rolling. Patient may cry or laugh, speak incoherently, or talk disconnectedly. Patient may have to be restrained. This is especially true with alcoholic and athletic patients. This stage can be entirely avoided by proper preliminary medication, by maintaining an open airway, and by not allowing the patient to talk from the start. Chloroform sleep may occur in children.

Third Stage, or Stage of Surgical Anesthesia.—Respiration becomes automatic or regular (this is the principal guide). The pulse drops to normal or below. Color is a slight pallor; muscles are relaxed; pupils contract to normal but respond to light; lid reflex is dulled; eyeballs are usually fixed; and there is a lowering of the body temperature.

Fourth Stage, or Overdose.—Respiration becomes more and more shallow, with sudden or gradual failure. The pulse is

weak, irregular, and thready; the color is one of extreme pallor, or blanching, especially around the mouth. The blood pressure continues to fall. Muscles show very great relaxation and flabbiness. Pupils, widely dilated, do not respond to light; lid reflex is absent, and the eyelids are partly open.

Elimination takes place principally through the expired air. A small part is broken down in the organism, thereby increasing the chloride content of the urine.

Indications.—(1) Mainly as an introduction to ether. (2) Prior to the use of the actual cautery. (3) For persons afflicted with epilepsy, tetanus, or convulsive seizures of any kind. (4) Pulmonary tuberculosis, asthma, emphysema, and pleurisy. (5) Aneurysm. (6) Trendelenburg position. (7) Obesity. (8) Insanity.

Contraindications.—(1) Weak, anemic children, with enlarged glands in different parts of the body. Status lymphaticus. (2) Prolonged operations. (3) Dental and minor surgery, when a safer anesthetic is available. (4) A sitting posture. (5) Very thin, septic, or weak, anemic patients. (6) Diabetics. (7) Low blood pressure from any cause. (8) *The presence of an open flame.*

After-Effects.—Occasionally, none. Usually, immediate slight nausea with or without vomiting. *Remote:* After prolonged operations, fatty infiltration of all organs, especially of the liver, heart, and kidneys. Even when given in repeated very small amounts, chloroform produces atrophic cirrhosis of the liver.

Comparison with Other Agents.—Its anesthetic strength as compared to ether is as 6 or 8 is to 1.

Administration

Drop Method.—This is probably the safest and best method. The *patient* should always be in a recumbent position, never sitting or semireclining. *The dropper:* always drop from the original container by placing a safety-pin by the side of the cork, or unscrewing the cap slightly. *Induction:* the anesthesia will go more smoothly if an alcoholic solution of the oil of bitter orange peel is first dropped

upon the mask (25 per cent oil of bitter orange peel, U. S. P., with 75 per cent of alcohol). Begin with one drop of chloroform on the mask; wait ten to fifteen seconds, then place two drops on the mask and after ten seconds add three to four drops every ten seconds. No time is wasted by beginning the administration slowly, and if conducted methodically, automatic respiration indicates surgical anesthesia after five to eight minutes, the first and second stages not being observed usually.

Maintaining Surgical Anesthesia.—About one-half the amount required for induction is needed to maintain anesthesia. This will be determined by the patient's reflexes. The patient must now be kept in the third stage. A lightening of the amount will cause vomiting, and a deepening will cause symptoms of shock to appear. When morphine has been previously given, the pupils are contracted throughout; otherwise, they will appear as already described. The anesthetist is guided by all signs, that is, by respiration, by circulation, by lid, pupil, and color reflex, and by the amount of anesthetic previously given.

The chloroform container may be dipped in a pan of hot water from time to time, to facilitate vaporization and to render the anesthesia safer. Probably the first sign of lightening up would be indicated by a tear, or secretion from the lachrymal gland; the next, would be the swallowing reflex. If the pulse becomes full and bounding, and lid reflex active, the dosage may be increased; as the reflexes become blunted again, the anesthetic should be decreased. The administration, if timed by a watch, relieves the anesthetist of a tremendous nerve strain and enables him to produce a continuous and safe narcosis. The head should be turned to one side, and the lower jaw supported, so as to maintain a clear airway at all times.

The Vapor Method.—This method consists of passing air, oxygen or other gases, over the surface of the chloroform, and allowing the patient to breathe an approximately known percentage of chloroform.

ETHER

Properties.—Pure ethyl ether is a colorless, mobile, strongly refractive, neutral, *inflammable* liquid, having a penetrating odor and a sharp burning taste. Its specific gravity is 0.718 to 0.719, or one-half that of chloroform, at 15/4° and it boils at plus 34.6° C. under 760 mm. pressure of mercury. By intense cooling, ether forms an ice-like solid which melts at –117° C. It is very volatile, slightly soluble in water (1 in 12 at plus 22° C.), and it dissolves little water (1 in 34 at plus 22°C.). It dissolves alcohol, benzine, and chloroform in all proportions; it is a solvent for fats and resins. The vapor is 2.6 times as heavy as air. Ether should never be used near an open flame, such as, a lighted gas jet, or a burning candle, or near a stove, a hot cautery, or arc lights.

How Made.—From ethyl alcohol and sulphuric acid.

Special Physiology

Effects upon the Respiratory System.—The first effect is stimulation, later, a slowing and decrease in depth, and finally there is respiratory paralysis. Rate, depth, and stertor of respiration are the safest guides to anesthesia. Its irritating effect upon the air passages produces a free secretion of mucus.

Effects upon the Circulatory System.—A lesion of the red blood corpuscles ensues. This lesion leads to agglutination and

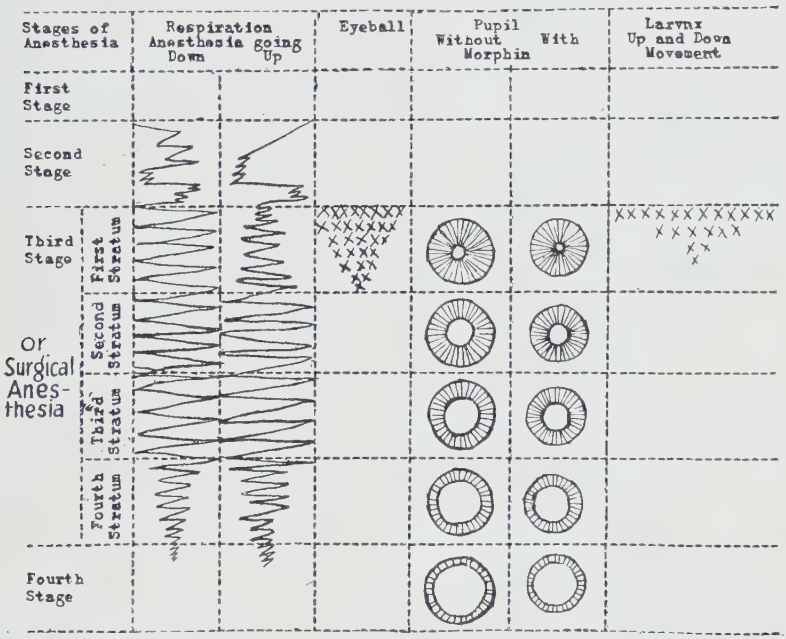


Fig. 2.—The original chart of A. E. Guedel, M.D., illustrating the physiologic effect of ether at various stages of anesthesia; with few modifications, applicable to all general anesthetics.

coagulation, and to the formation of fibrin. The number of red blood cells is diminished, indicating the destructive influence of the agent. Ether is a direct heart stimulant during the early stages of its administration, becoming a cardiac depressant only in the later stages, or when a toxic amount is employed. When this occurs, arterial dilatation, slowing of the pulse, and fall of blood pressure result, but cardiac failure always *follows* failure of respiration. If the ether is properly administered, circulation

is dependent upon respiration. No fatal case of reflex inhibitory arrest has ever been reported.

Effects upon the Nervous System.—The first effect is stimulation; later, progressive paralysis, (1) of the higher cerebral centers, involving the intellectual faculties; (2) of the lower cerebral centers, sensation and motion; (3) of the spinal cord involving sensation and motion; and (4) of the medullary centers, involving vital function. Sensation is lost as follows: (1) back and extremities; (2) genital organs and rectum, and (3) parts supplied by the trigeminus nerve.

Effects upon the Muscular System.—Ether may produce a state of clonic contraction, or ether tremor. As administration proceeds, there is general muscular relaxation. Spasm of various parts of the muscular system, such as, the tongue, and the masseter, the laryngeal muscles, and the muscles of the neck, chest, and abdomen, may occur, giving rise to respiratory embarrassment and other complications.

Effects upon the Glandular System and Other Structures.—The irritating effect upon mucous membranes of the upper air passages, causes a hypersecretion of mucus, from which fatal asphyxia may follow. There may be overactivity of the mucous glands of the stomach and of the intestines. Albumin occurs in 36 per cent of cases, but it usually promptly subsides. The secretion of milk in nursing mothers is negative.

Cause of Death.—Respiratory failure, as a result of an overdose or obstruction of the air passages. *However such failures may arise, the circulation at the moment when breathing ceases is sufficiently satisfactory for remedial treatment to be almost invariably successful.* Henderson believes that all deaths under anesthesia are fundamentally due to acapnia, resulting from excessive pulmonary ventilation during the stage of excitement.

Stages of Ether Anesthesia (see Chart)

A few drops of the alcoholic solution of oil or bitter orange peel renders the pungent odor less disagreeable.

First Stage, or Light Anesthesia usually occupies two minutes. Respiration becomes accelerated; the blood pressure is increased; the pulse is full and bounding, and the color reflex is

heightened. If ether vapor is too concentrated, there may be swallowing, closure of the glottis, holding of the breath, a feeling of suffocation, muscular rigidity, coughing, and turning of the head from side to side. The pupils become dilated.

Second Stage, or Stage of Excitement may and can be avoided by modern technic. Respiration is irregular; pulse becomes rapid, full, and bounding; patient may have cessation of breathing for variable lengths of time. "Ether tremor," patient shaking with noticeable violence, may occur. This disappears upon deepening the anesthesia. Mucus and saliva are freely secreted. The face is flushed, and cyanosis may occur. Crying, singing, laughing, shouting, and struggling may also occur. There is marked rigidity of the muscles, with clonic and tonic contractions. The blood pressure is raised.

Third Stage, or Stage of Surgical Anesthesia.—Respiration is regular, deep, and slightly stertorous; pulse is full, bounding, and regular, usually ten to twenty beats above normal. Face becomes flushed; blood pressure remains constant. Pupils, slightly dilated, respond to light; eyeballs are usually fixed, but may be rolling. There is a relaxation of all muscles. Lid reflex is weakly present; phonation is absent. A return to a lighter stage may be indicated by lachrymation, phonation, weak respiration, pallor of face, swallowing movements, or dilated pupils. All of these phenomena call for an increased amount of the anesthetic.

Fourth Stage, or Overdose.—Respiration is weak; cyanosis appears; the pulse is soft, feeble, and irregular, the pupils are dilated and show no reaction to light; the eyeballs are fixed and dry; the eyelids are separated; muscles become flaccid and blood pressure is decreased.

Elimination of ether is accomplished almost entirely through the lungs and, as compared with chloroform, very rapidly. One investigator found 150 mg. per 100 c.c. of blood immediately after the cessation of the inhalation. Only one-half of this amount was demonstrable after five minutes. Traces were found after a few hours, but none at all after four hours.

After-Effects.—The *immediate* effects are usually retching, nausea, and vomiting. There may be mental disturbances, and

mania and dementia have been reported. Cerebral hemorrhage and pulmonary complications have been noted.

Remote: Never as severe or as frequent as follow the use of chloroform.

Otte recommends inhalations of warm water vapor with admixture of thymol and salicylic acid immediately after narcosis.

Administration

Open or Drop Method.—It is best to drop the ether from the original container, rather than to pour the contents into some patented dropper, as it is important to maintain the original purity of the ether. The usual ether mask covered with gauze and surrounded by a towel is sufficient. As previously stated, the administration should be begun by a few drops of oil of bitter orange peel upon the mask. The ether should be increased gradually, as with chloroform, until the patient is fully under its influence, as indicated by automatic respiration, after which time very little ether is required to keep the patient surgically anesthetized. The skin incision requires a deep anesthesia, the depth depending more upon the surgeon's ideas than upon the patient's condition. Panting and rapid breathing or irregular stertorous breathing indicate that the patient needs more air. The commonest methods of inducing ether anesthesia are by using the essence of orange, the chloroform-ether sequence, the ethyl-chloride-ether sequence, or the nitrous-oxide-ether sequence.

Ether can be administered by the open, closed, or vapor method; by the endotracheal, endopharyngeal, or intravenous method, or by the oil-ether colonic method. Ether is unquestionably the safest general anesthetic known today. But for the nausea and vomiting that follow the open or closed methods, no other anesthetic would be thought of. The oil-ether colonic anesthesia obviates these unpleasant by-effects. As this method is used principally for operations around the head, such as excision of the tongue or jaw, or for extensive dental work, it is of vital importance to dentists. The technic is as follows:

The patient has one soapsuds enema, followed by two clear water enemas, thirty minutes apart. The patient should then be permitted to rest for two or three hours, or preferably until the next morning. Two hours before operation, the patient should go to the toilet for the last time. When he returns to bed, insert a ten-grain chloretone suppository, at the same time giving by hypodermic one-eighth, one-sixth, or one-quarter grain of morphine in 2 c.c. of sterilized 50 per cent solution of magnesium sulphate. One hour before operation, with the patient on his left side, insert a catheter four to six inches into the rectum, the tube and funnel having previously been filled with oil. As the oil leaves the funnel, follow it with the mixture of oil-ether. This consists of three to six ounces of ether with one-half the amount of oil and two drams of paraldehyde. Pressure should be made upon the perineum with the towel for five or ten minutes, after which time the tube may be withdrawn and the patient allowed to lie in whatever position is most comfortable. Fifteen to twenty minutes before operation, if the patient is not asleep, an additional injection of magnesium sulphate, with one-eighth grain of morphine may be given. The possibility of infection is lessened, inasmuch as the colon bacillus is killed within five to ten minutes.

ETHYL CHLORIDE

Properties.—Ethyl chloride is a colorless, mobile liquid at low temperature and is exceedingly volatile. It possesses a sweetish taste and a pungent, yet fragrant ethereal odor. It is inflammable, burning with a smoky, green-edged flame, hence, care must be exercised in using it near an open flame or a hot cautery. It even decomposes when very close to a hot bulb or an incandescent electric light. It possesses a boiling point of plus 12.5° C.[5], and its specific gravity is 0.92138 at 0°[6]. The vapor has a specific gravity of 0.91708; the vapor density is 2.22. Ethyl chloride is readily soluble in ethyl alcohol and ethyl ether. It dissolves phosphorus, sulphur, fats, oils, and many resins. Water dissolves about one-fiftieth of its weight of ethyl chloride and acquires a sweetish ethereal taste.

How Made.—With alcohol and hydrochloric acid.

Containers.—Ethyl chloride is supplied in mechanically capped glass tubes of convenient form, where it is held under pressure. It should be kept in a dark cool place remote from lights or fire.

Physiologic Considerations

Effects upon the Respiratory System seem to be pathologic rather than physiologic; as blood pressure falls, respiration ceases, and vice versa. Ethyl chloride quickens and deepens respiration.

Effects upon the Circulatory System.—Very little ethyl chloride is taken up by the blood serum, and it is taken up only in small amounts by the blood corpuscles. It has a paralytic effect upon the heart muscle. In full surgical anesthesia, a great fall of blood pressure takes place. It causes dilatation of the vascular system; the flushing of the face is due to dilatation of the peripheral vessels. Vagus inhibition may occur, but is not as probable as with chloroform.

Effects upon the Nervous System.—There is a double action, —a direct chemical action and an indirect one due to cerebral anemia caused by paralysis of the vasomotor center.

Effects upon the Muscular System.—Muscular rigidity is present almost as often as relaxation. Opisthotonos position may result. The masseter muscle is especially affected.

Effects upon the Glandular System.—The secretions of the liver and kidney are diminished.

Causes of Death are either (1) simple overdosage, or (2) asphyxia, caused by respiratory rigidity. If death is caused by an overdose, the symptoms are pallor, pulselessness, arrest of breathing, wide dilatation of the pupils, general muscular flaccidity, and separation of the lids. Cardiac arrest quickly follows. If due to asphyxia, the symptoms are spasm about the jaws, mouth, tongue, larynx, or respiratory muscles.

Stages of Anesthesia

The First Stage is an analgesic stage, commencing after two or three breaths of the anesthetic. This is the stage before stertor or other signs of anesthesia appear. It is sufficient to open an abscess, but the operator may cause pain unless he works rapidly, as the analgesia lasts only thirty seconds.

The Second Stage is a truly anesthetic stage, which lasts from one to three minutes after removing the mask from the face. This stage may deepen after the removal of the mask, owing to the absorption of the ethyl chloride from the lower air passages. A dental prop must be inserted between the teeth in all cases, on account of the frequent spasm of the masseter. This must be done before beginning the administration.

The Third Stage is again one of analgesia. It lasts from thirty to forty seconds, during which no sensation is felt, but the patient may talk or move slightly. Just before the patient becomes conscious, swallowing occurs for some time. The first sense to return is hearing, and the next is sight.

The Fourth Stage is that in which the bulb is affected, causing cessation of respiration, arrest of the heart, and death.

Signs of Anesthesia. (1) A quick, deep, and regular respiration; (2) eyeballs fixed or rolling; (3) face slightly flushed; (4) muscular relaxation or rigidity; (5) pupils widely dilated, and (6) absence of conjunctival or corneal reflexes.

The Danger Signals are cyanosis, respiratory embarrassment, spasm of the jaw, and increasing stertor.

Overdose symptoms are widely dilated pupils, great pallor, and intermittent respiration.

After-Effects.—The albumin test is negative. There is no injurious effect upon the blood corpuscles or the kidney. Sometimes the patient has severe diarrhea. Vomiting occurs in 15 to 20 per cent of cases; nausea and headache in over 20 per cent of cases. Erotic thoughts and dreams may occur. Fainting and collapse seem to occur oftener than with the other anesthetics.

Excretion takes place mainly through the lungs.

Indications.—*Children*, all authorities agree, are the best subjects for short operations; also very aged and anemic patients.

Contraindications are for athletes, alcoholics, and smokers; for those who have any airway obstruction, feeble heart action, or in cases where absolute muscular relaxation is required.

Administration

Open, Semiopen, or Closed Method.—The safety key to ethyl chloride administration lies in insuring a clear airway by supporting the jaw with the finger under the symphysis. There is no contraindication to administering ethyl chloride with the patient in a sitting position. The appearance of a patient under ethyl chloride is unattended by either *cyanosis or pallor*, as may happen with the administration of either nitrous oxide or chloroform; hence, the limits of safety may be easily overstepped.

Open Method.—An ordinary chloroform mask is used. The ethyl chloride is administered drop by drop or sprayed intermittently upon the mask until anesthesia ensues. Care must be taken to stop the administration immediately upon rigidity or spasm. Respiration must be free and clear at all times.

Semiclosed Method.—Martin Ware has perfected the simplest and possibly the best ethyl chloride mask extant. The apparatus consists of a rubber face-piece into which a brass tube is inserted; a few layers of gauze are placed between the tube and mask; a stream of ethyl chloride is directed on the gauze intermittently, thus approximating the drop method of chloroform. A layer of frost quickly forms on the gauze, due to freezing of the watery vapor of the expired air; as this frost covers the gauze, a hissing noise is heard as the patient goes into the third stage of anesthesia. If the gauze is entirely covered with ice, the mask should be immediately removed upon inspiration and replaced again upon expiration. Ware estimates the failures of this method as about 5 per cent. By failure is meant a prolonged period of excitation.

Closed Method.—As the closed method, according to all statistics, is slightly more dangerous than the open or semiopen method, and requires more experience for its administration, details will not be given here.

Somnoform.—A mixture of 5 per cent ethyl bromide, 60 per cent methyl chloride, 35 per cent ethyl chloride. Ethyl chloride is preferable, as the mixture has a tendency to decompose.

Anesthol (introduced by Willy Meyer in 1898).—It is a clear transparent fluid of agreeable odor, composed of 17 per cent

ethyl chloride, 35.89 per cent chloroform, and 47.19 per cent ether. It has a specific gravity of 1.045, which approximates the specific gravity of blood (1.056-1.059). Its boiling point is 104° F. (40° C.). This anesthetic is used principally as a preliminary to ether anesthesia.

Ethyl Chloride and Chloroform should not be used together, as both are cardiac poisons, respiratory depressants, and both act quickly.

NITROUS OXIDE

Properties.—Nitrous oxide is a colorless gas at ordinary temperature. Its specific gravity is 1.527. Under a pressure of 50 atmospheres at plus 7° C. it is converted into a colorless, mobile liquid with a density of 0.937 at 0° C. The liquid has the lowest refractive index of all liquids. It is marketed as a liquid in steel cylinders of various capacities. It may be preserved with perfect safety indefinitely in steel cylinders with good valves. Nitrous oxide is soluble in water volume for volume at 0° C. The solubility diminishes greatly on elevation of the temperature of the water. It is quite soluble in absolute alcohol at 0°.

Chemical Properties.—It is quite stable, not being decomposed by heat unless the temperature is very high. Nitrous oxide supports combustion when started. A strongly burning taper is not extinguished when plunged into the gas, but continues to burn, utilizing the oxygen, and liberating the nitrogen. It has a pleasant odor and sweet taste, and may be respired without discomfort, as it has no irritant properties.

How Made.—By heating ammonium nitrate.

Physiologic Considerations

Effect upon Respiratory System.—Respiration becomes more rapid and deep, then convulsive; and, as the deoxygenation process is continued, it becomes slow and shallow, finally ceasing altogether. Numerous experiments show that the usual post-mortem signs of asphyxia are present when death occurs. It is not injurious to the lungs.

Effect upon the Circulatory System.—There are no chemical changes of any kind, but merely a physical solution in the blood.

No permanent diminution of hemoglobin, no increased hemolysis, and no direct effect upon the heart results from nitrous oxide. Blood pressure is increased with the pure gas.

Effects upon the Nervous System.—First pleasurable or not, according to the individual; then the senses become more acute, followed by analgesia, anesthesia, and asphyxia.

Effect upon the Muscular System.—Relaxation or rigidity.

Effects upon the Glandular System.—No effect upon the kidneys or other organs. If nausea or vomiting occurs, it is due to deoxygenation.

Causes of Death.—Death is usually due to deprivation of oxygen, or asphyxia. The heart continues to beat after respiration has ceased, which proves that death is not due to failure of the circulation. Asphyxial anesthesia may possibly induce rupture of blood vessels in the brain.

Stages of Anesthesia

First Stage.—A feeling of warmth and a numbness in the limbs, followed by a feeling of exhilaration, accompanied by an impulse to breathe more rapidly and deeply. Pulse is full and bounding; blood pressure is raised. Thirty to forty seconds is the duration of this stage, and it ends with unconsciousness.

Second Stage.—There may be laughing, muttering, crying, and incoordinate movements. Exhilaration rather than depression marks the second stage of "laughing gas." Fanciful, erotic dreams may occur and persist after the return of consciousness. The pulse is full and increased in rapidity. Pupils are dilated; eyelids may be opened or closed. There may be a duskiness or a lividity. *Hearing continues during this phase.* No surgical intervention should be attempted. Time, thirty to forty seconds.

Third Stage, stage of surgical anesthesia, is induced in one to four minutes, the time depending entirely upon the patient, whether or not preliminary medication has been given, and on the technic used. The breathing is automatic, regular, and usually without noise. The pulse slows down to normal, or it may be between 80 and 90. Lid reflex becomes dull; muscular relaxation is more or less complete. As nitrous oxide is stimu-

lating, the patient must not be allowed to return to the second stage. Two or three stertorous respirations indicate complete anesthesia.

The Fourth Stage, or stage of overdose, supervenes through some error of technic, and asphyxia becomes the predominant feature. Breathing becomes embarrassed; there is first hyperpnea (excessive breathing), then dyspnea (difficult breathing), general muscular spasms, and violent or convulsive expiratory efforts. Pupils become widely dilated, lids open, conjunctivae insensitive; pulse imperceptible; respirations prolonged and gradually ceasing; paralysis of the respiratory centers becomes complete, and death supervenes. Marked cyanosis usually accompanies this stage, but asphyxia may occur without this being very noticeable.

Elimination occurs entirely through the lungs. In two minutes the blood is practically free of the gas.

After-Effects are usually absent, but there may be nausea and vomiting if cyanosis is allowed for any length of time.

Indications.—Nitrous oxide should always be administered with a small amount of oxygen. No attempt should be made to give this gas alone or, in other words, to push it if the patient is not under the influence in three to four minutes. Ethylene, or warmed ether, should be added in order to complete the narcosis. It is especially indicated in phthisis and for short operations, such as extraction of teeth, opening abscesses, etc.

Contraindications.—Very young children (under four years) are not good subjects. Old persons or adults whose arteries are sclerosed, contraindicate nitrous oxide and oxygen. Strong, muscular, athletic, alcoholic, and obese subjects, or persons with any obstruction of the air-passages, are not good subjects for nitrous oxide and oxygen.

Administration

When oxygen is used with nitrous oxide, a safer, deeper, and more satisfactory anesthesia is obtained than is possible with air. The objection to using air is the large percentage of nitrogen, which is useless for anesthetic purposes. As stated by Hewitt, when air is given the equation reads like this:

Air (by volume), 40 per cent = { 8 per cent oxygen / 32 per cent nitrogen
Nitrous oxide, 60 per cent = 60 per cent nitrous oxide

Sixty per cent of nitrous oxide is insufficient to produce anesthesia; while 8 per cent of oxygen is amply sufficient to maintain anesthesia. By using oxygen instead of air, the equation would read like this:

Oxygen = 8 per cent (by volume)
Nitrous oxide = 92 per cent (by volume)

This is about the average for adult patients, and is satisfactory. Regardless of the apparatus used, the administration with the face-mask is as follows:

Technic.—It is perfectly justifiable to have two to four complete inhalations of nitrous oxide alone, preparatory to the administration. (It is never justifiable to asphyxiate a patient and then give oxygen, and repeat the procedure.) If there is marked sclerosis of the blood vessels, it is best to give oxygen from the start. Accidents have occurred by attempting to push the anesthetic without adding ethylene or ether, in order to complete the narcosis. The mask should fit closely and be absolutely air-tight. The percentage of oxygen varies between 5 and 8 per cent, according to the age, size, and condition of the patient. If the patient is not in automatic respiration in two to four minutes, the nitrous oxide should be increased. The oxygen should never be decreased to such a point that there is marked cyanosis. Slight positive pressure, 1 to 4 mm. of mercury, facilitates the induction and maintenance of the anesthesia. Rebreathing at times also increases the analgesia.

With Nasal Inhaler.—The principal thing about the nasal inhaler is that it should fit snugly. In small children, the top may be up as high as the forehead, but if air is excluded this will make no difference. Have the expiratory valve open, and instruct the patient to breathe through the nose. This will be facilitated by holding a rubber mask over the mouth, thus making mouth-breathing impossible. Administer nitrous oxide alone for four to six inhalations; then add a small amount of oxygen. Anesthesia comes on more slowly with this method than with the face-mask. Sufficient pressure should be added to both nitrous oxide and oxygen to force the gases through the nose, in other words, this pressure must be sufficient to overcome any mouth-breathing. This method is not so smooth as with the face-mask, but with ethylene, the patient can be freed from all physical pain. This anesthesia can be kept up indefinitely by regulating the oxygen and nitrous oxide in accordance with the patient's symptoms.

THE HYDROCARBON GASES

Of the fourteen hydrocarbon gases, ranging in value from acetylene, C_2H_2, to octave C_8H_{18}, only the first two seem available for use in man.

ACETYLENE (C_2H_2)

Rosemann and Grehants' animal experiments in 1895, and Weiland's in 1924, determined the anesthetic qualities of acetylene. Weiland kept animals in deep surgical anesthesia for ten hours, with complete recovery in a few minutes when exposed to fresh air. There was no effect upon any organ or tissue of the body except the central nervous system. Acetylene is a simple physical solution in the blood. Its high explosibility seems to be its only objectionable feature.

Upon administration, there is a slight rise in blood pressure which returns to normal in less than twelve minutes and remains normal. Slight vomiting occurs in 15 per cent of cases. Weiland found 55 per cent acetylene and 45 per cent oxygen was the proper amount, while Hooper and Gwathmey used 53 per cent acetylene and 47 per cent oxygen (differences that could easily be explained by the use of different apparatus).

Clinically, acetylene has passed the experimental stage, Gauss in Germany, reporting over 2,000 surgical cases, and Goldman Brothers of New York City an equal number of dental administrations. For surgical cases, Gauss' technic is as follows:

> For first few breaths, 70 to 80 per cent acetylene; whereupon a quick reduction is made to 40 to 50 per cent acetylene and 60 to 50 per cent oxygen, and this ratio is maintained throughout the operation.

The technic for dental cases, using a nasal inhaler, is about the same as with nitrous oxide, the average amount being acetylene, 40 per cent and oxygen, 60 per cent.

ETHYLENE (C_2H_4)

Properties.—Ethylene is a colorless gas with a sweetish, slightly disagreeable odor and a molecular weight of 28.04. It is slightly soluble in water (0.149 c.c. at 20° C.), and readily in alcohol and ether. It liquefies at 10° C., under a pressure of 60 atmospheres. It forms with air or oxygen a *highly explosive* mixture.

How Made.—By the action of absolute alcohol with orthophosphoric acid or kaolin.

Distribution.—It is found in illuminating gas, 4 to 22 per cent; also in the exhaust from gasoline engines.

Physiologic Effect

Effects upon Respiration.—If asphyxia is absent, the respiration center is normal, and respiration is slow, regular, and shallow. Respiration fails before circulation.

Effects upon the Circulatory System.—The heart is not affected in light anesthesia but is slowed down in deep anesthesia; the blood pressure is lowered (10 to 15 mm. Hg.); a general vasodilatation seems to form with hemoglobin a specific but easily dissociable hemoglobin derivative, of cherry-red appearance.

Effects upon the Nervous System.—The olfactory sense disappears after three or four full inhalations. Reflex swallowing ceases at about the same time, and consciousness is lost almost immediately afterward. Analgesia comes on just before the third or surgical stage.

Effects upon the Muscles.—Much better relaxation is secured than with nitrous oxide, but not as good as with ether.

Effects upon the Glandular System.—The sweat glands are not stimulated. Thus the patient remaining warm and dry, conserves energy. *Salivary glands* are not overstimulated.

Effects upon the Mucous Membranes.—No effect.

Kidneys.—No effect; nephritis is no contraindication to the use of ethylene.

Postanesthetic Effect.—Sixteen per cent of patients vomit just prior to awakening; 30 per cent vomit several times after awakening.

Cause of Death is deprivation of oxygen.

Elimination.—The major portion is promptly eliminated by the lungs.

Technic of Administration

For *surgical cases* anesthesia is best accomplished when ethylene is combined and used sequently with nitrous oxide; first, a few breaths of nitrous oxide (4 to 6) to wash out the lungs; then a decrease of the nitrous oxide followed by ethylene (proportion now being 50 per cent of each) and oxygen 10 to 20 per cent. The ethylene and nitrous oxide can now be decreased or increased according to the condition of

TABLE I

COMPARISON OF ANALGESIC AND ANESTHETIC DOSES OF ETHYLENE, NITROUS OXIDE AND OXYGEN, AND ETHYLENE AND OXYGEN WITH AND WITHOUT PRELIMINARY MEDICATION

GAS	HOLES	PER CENT	EXPLOSIVENESS	RESULTS OBTAINED	
				WITH PRELIMINARY MEDICATION	WITHOUT PRELIMINARY MEDICATION
Ethylene Nitrous oxide Oxygen	4 2 2	66 20 14	Burns	789. Complete analgesia with absence of eye and tail reflexes. Anesthesia. Maintains dorsal position after 3 minutes. 790. Ditto.	792. Complete analgesia with absence of eye and tail reflexes. Does not assume dorsal position. 791. Incomplete analgesia. Eye reflex absent. Tail reflex obtained.
Ethylene Oxygen	3 1	87 13	Explodes	859. Complete analgesia with absence of eye and tail reflexes. Does not maintain dorsal position. 860. Ditto	861. Complete analgesia with absence of eye and tail reflexes. Does not maintain dorsal position. 862. Ditto.

the patient, i. e., if the patient has a tendency to respond to reflexes, increase the ethylene only, or additionally decrease the nitrous oxide; if the patient's pulse is slow, below 70, with all reflexes obtunded, increase the nitrous oxide or decrease the ethylene. Three to five minutes before the operation is concluded, shut off the ethylene entirely, at the same time increase the nitrous oxide. Finally discontinue the nitrous oxide and wash out the lungs for a few breaths with oxygen. In this way the disagreeable by-effects of ethylene can be eliminated to a very great extent.

PROPYLENE (C_3H_6)

This gas was first investigated by Meyer and Hopff in 1923; white mice were narcotized in eight minutes by a 50 per cent mixture of C_3H_6 and air. Halsey next stated that propylene was two to three times as powerful as ethylene with a fairly wide margin of safety. Brown confirmed the above results, i. e., anesthesia was produced with 50 per cent to 37 per cent propylene. Riggs states that as propylene can be administered with larger amounts of oxygen this would seem to favor its introduction. Ethylene 90 per cent, acetylene 78 per cent, propylene 40 per cent is the equivalent anesthetic potency. Riggs states that animals showed no ill effects after seven and a half hours of deep anesthesia, however, the range between anesthesia and respiratory failure is large. Halsey later made electrocardiographic studies of the hearts of animals. In concentrations which were less than sufficient to induce or maintain anesthesia (25 per cent to 40 per cent) ectopic ventricular beats occurred, and with higher concentrations ectopic ventricular tachycardia resulted. Ectopics were not observed with the other anesthetics. These conditions promptly ceased when the gas was discontinued or the concentration lowered. Propylene may be considered still in the experimental stage.

CARBON DIOXIDE

Carbon Dioxide, carbonic acid (CO_2) is a heavy colorless *incombustible* gas. The normal CO_2 percentage in the alveolar air is 5.6 per cent. A rise of 0.2 per cent of CO_2 (1.6 mm.) in the alveolar air *doubles* the respiration. Acapnia, i. e., a slight reduction (0.2 per cent) of the CO_2 produces apnea (a transient cessation of breathing). CO_2 produces, after absorption, strong medullary stimulation, and in higher concentrations, narcosis. It is useful against nausea.

Hickman's animal experiments (1820-1828) demonstrating the value of carbon dioxide as an anesthetic have been fully verified in the laboratory by Gwathmey and Hooper (1925-1926), CO_2, 47 per cent and, O_2, 53 per cent, produce analgesia and anesthesia in two minutes, but this combination is unsatisfactory in lower and dangerous in higher concentrations. If anesthesia is maintained for any length of time with CO_2, death ensues at a later period from congestion of the lungs. From our animal experiments we conclude that CO_2 should not be used as an anesthetic per se.

Lundy (March 19, 1924) was the first to use CO_2 as a respiratory corrective or stimulant. In the initiatory stage, if the patient hesitates or holds his breath, a small amount of CO_2 is added, which immediately corrects the apnea, and a smooth anesthesia results.

Henderson and his associates* suggest the use of CO_2 for all etherization. The small percentages used by Lundy and Henderson for the purposes mentioned would have no deleterious effect upon the lungs.

"Carbon dioxide *is* nature's own stimulant to the respiratory center" (Henderson), hence, every apparatus for administering nitrous oxide and ethylene, should also have an attachment for administrating carbon dioxide with oxygen, when indicated.

TABLE II

COMPARISON OF ANALGESIC AND ANESTHETIC DOSES OF PROPYLENE, ACETYLENE, ETHYLENE AND NITROUS OXIDE WITH AND WITHOUT PRELIMINARY MEDICATION

GASES	RESULTS OBTAINED			
	WITH PRELIMINARY MEDICATION		WITHOUT PRELIMINARY MEDICATION	
	COMPLETE ANALGESIA	ANESTHESIA	COMPLETE ANALGESIA	ANESTHESIA
	Per cent anesthetic gas	Per cent anesthetic gas	Per cent anesthetic gas	Per cent anesthetic gas
Propylene oxygen	28	50	50	50
Propylene air	36	46	46	46
Acetylene oxygen	41	41	75	75
Ethylene oxygen	73	92	87	94
Nitrous oxide oxygen	91	93	93	93

COMPARATIVE VALUE OF ALL THE GENERAL ANESTHETICS

According to the laboratory work of Gwathmey and Hooper, and statistics not yet published, we may conclude that statistics

*Jour. Am. Med. Assn., March 20, 1920.

previously given of nitrous oxide are misleading. Nitrous oxide is the least desirable of the gases, since in order to obtain analgesia with this gas we must also obtain anesthesia, i. e., the patient must be in the third zone of the third stage of anesthesia. When preliminary medication is not used ethylene is the only gas that gives any value as between analgesia and anesthesia, 7 per cent oxygen without preliminary medication and 19 per cent oxygen with preliminary medication. When nitrous oxide and ethylene are combined a synergism seems to result, as a much higher percentage of oxygen can be used than with either gas alone. Ethylene and oxygen are explosive; ethylene, nitrous oxide, and oxygen support combustion but are nonexplosive.

PRELIMINARY MEDICATION

Fear of the dentist's chair is universal and common to all mankind. Even for ordinary work, such as extractions or any painful manipulation, in addition to the local agent or inhalation anesthetic, the majority of patients would be benefited by some form of preliminary medication.

Before this method can become as universal in observance as its omission is now customary, the mental attitude of the dentist must be changed. With some patients even a placebo would have a beneficial effect. Patients *dying* from fright emphasize the need, occasionally, for all. Kappelar (Anesthetica p. 18) relates the case of a man dying from fright before the agent was used at all. Simpson (Works, Sir James Y.) relates the death of a patient while the groin was being shaved preparatory to an operation. The Lenox Hill Hospital had a death from fright within recent years. To counteract this element of fear, the majority of dentists do nothing. However, one dentist, whenever possible gives all of his patients chloretone grains x, in capsule one hour before operation. For longer operations (in hospitals) dental patients are better protected from psychic shock and actual physical pain with some form of preliminary medication that will render them either unconscious or nearly so. The ideal for oral surgery is oil-ether colonic anesthesia, as the patient goes to sleep in his own bed, oftentimes unaware that an anesthetic is being administered, while the surgeon has the field of operation to himself. Where this method is not under-

stood or is inadvisable, a patient, two hours before operation, may be given an intramuscular injection of 2 c.c. of a 50 per cent solution of magnesium sulphate combined with 2.5 per cent novocaine and ⅛ grain morphine sulphate. This may be repeated once or twice at thirty minute intervals, and supplemented at operation with ethylene, nitrous oxide and oxygen 10 to 40 per cent. If, however, the psychic element is much in evidence, or if the patient is athletic or alcoholic, in addition to the above preliminary treatment the following retention enema may be given forty minutes before operation:

Ether .....two and a half ounces
Paraldehyde....two drams
Olive oil.....sufficient to make four ounces

This combined medication will render the patient indifferent to surroundings or possibly unconscious, but full surgical anesthesia with relaxed tongue does not occur. It can, therefore, be given with full assurance as to its safety.

At operation, it must be supplemented with novocaine, one-half per cent for local analgesia, or with ethylene and nitrous oxide and oxygen 30 to 80 per cent.

EMERGENCY MEASURES

Regardless of the operation, anesthetic used, or method of administration, if respiration suddenly ceases and the pulse disappears the treatment is as follows:

First, withdraw the anesthetic; second, restore an open airway, if this is obstructed, by pulling out the tongue or using a breathing tube or by inserting a mouth-gag; third, a *quick, vigorous slap on the chest;* fourth, *immediate lowering of the head* (if the subject is an infant, it should be suspended by the heels and be given a pendulum swing); fifth, *dilatation of the sphincter ani;* sixth, *the application of hot or cold cloths to the face.* If these measures are insufficient, *use artificial respiration:* (a) Grasp the arms of the patient near the elbows, pressing them firmly against his sides, thus clearing the air passages of noxious vapors; hold this position for two seconds; (b) now draws the arms laterally below the head and hold this position for two seconds; repeat the entire procedure fifteen times a min-

ute. An assistant may massage the precordial region, along with intermittent dilatation of the sphincter ani. Use no hypodermics. Traction of the tongue sometimes stimulates respiration.

These measures must be continued for at least thirty minutes or until natural respiration is restored. If shock is caused by loss of blood, intravenous saline infusion should be instituted after tying the blood vessels. Warmth to the body and a recumbent position should be maintained until normal function is restored.

CHAPTER II

THE DEVELOPMENT OF LOCAL ANESTHESIA

Local anesthesia was undoubtedly the first type of anesthesia to be used empirically, and it is also the form of anesthesia in which the greater scientific interest lies at the present time. It is the most satisfactory type of anesthesia as far as the effect upon the patient is concerned and, if the patient's confidence and cooperation can be secured, in the general conduct and expense of the operation. Local anesthesia has also been one of the most important factors in the development of modern highly specialized surgery.

Compression of nerve trunks was the first method of local anesthesia of any real service. The observation that patients with neuralgia and other painful affections instinctively tried to lessen their pain by pressure upon the affected parts; also that paralysis occasionally followed accidental pressure on the nerve trunks; and, again, that disturbance of sensation followed the binding of a limb to prevent hemorrhage during amputation, were possibly the reasons for popularizing this method.

The method of ligating a limb with the aid of a stick originated in antiquity. Among the early Assyrians, pressure was used on blood vessels to produce anesthesia in the customary operation of circumcision. During the Greek and Roman periods, this type of anesthesia apparently was not practiced. Ambroise Paré, in 1543, revived the method and throughout the succeeding centuries one sees compression or ligation anesthesia advocated in one form or another, only to be again discarded. The Esmarch elastic bandage is its present application. The uncertainty of the anesthesia thus produced and the dangers of pressure paralysis and gangrene have rendered its use impractical.

Pain-quieting applications containing drugs have been employed in surgery since ancient times. Dioscorides in the first century A.D. discusses the local application of preparations of Mandragora and other atropine-containing plants for the relief

of pain. In the middle ages the local use of narcotic drugs for the relief of pain in surgical operations was a common practice. The application of these drugs was based upon the supposition that remedies which were useful in the artificial production of sleep must be likewise of use for local anesthesia if applied to the skin. We know now that suggestion and autosuggestion played a large rôle in any results that may have been thus obtained, because a sufficient amount of the drugs could not have been absorbed through the unbroken skin to produce a satisfactory anesthesia.

The application of cold as a local anesthetic agent was introduced in the sixteenth century by the Italian anatomist and surgeon, Severino, through his pupil, Bartholinus. In 1773, Thomas Percival, who wrote the first "Code of Medical Ethics," described in an essay "On the Medicinal Use of Fixed Air" the properties of carbon dioxide in relieving the pain of raw wounds, when blown against denuded surfaces. The first carefully conducted experiments with the object of securing local anesthesia were made by Sir Benjamin Ward Richardson. He noted the anesthetic effects of cold applied locally, and studied the effects of rapid evaporation of volatile liquids in producing cold at a given spot on the skin. In 1867, he introduced what has been termed the Richardson ether spray, for the purpose of producing a satisfactory local anesthesia, and this method was in general use for many years. It was later modified by the use of ethyl chloride, a substance which evaporates more rapidly than ether, and hence, leads to the desired results more effectively.

The freezing process acts as a terminal anesthetic and if properly applied produces complete anesthesia of the mucous membrane and skin. Its field of usefulness, however, is limited to operations which involve only the superficial structures. If used in cases of pulpitis or acute pericementitis, it causes terrific pain. Prolonged or extensive freezing is apt to cause sloughing, and even in limited areas the return of tissues to their normal state is accompanied by severe pain.

Electricity has also been exploited as a local anesthetic. Richardson's "Voltaic Anesthesia" was used quite extensively by the medical profession in 1855. The method consisted in the application of the positive electrode of the galvanic current to

the skin, the sponge of the electrode being wet with aconite and chloroform. Francis, in 1858, recommended the attachment of the electric current to the forceps for the painless extraction of the teeth. It has since been found that the electric current is not a local anesthetic agent, and the method has been justly discarded as worthless.

The introduction of the hypodermic syringe by Alexander Wood, of Edinburgh, in 1853, made local anesthesia possible

Fig. 3. Artist's reconstruction of primitive surgery among the Peruvian Indians. The operator chewed cocoa leaves, permitting the saliva to flow on the wound to induce anesthesia. (From Moodie.)

through the physiologic action of special drugs. His discovery made possible the injection of solutions of various drugs into the tissues where they could come into more intimate contact with the nerve supply and there exert their chemical and physiologic action. Wood immediately began to inject morphine and tincture of opium in the neighborhood of nerve trunks for the relief of neuralgia. Injections of morphine were also used in the following year for the removal of toe nails, and for cauterization of wounds and ulcers. Success was reported, but the relief was

due no doubt to the systemic action of the morphine rather than to its local action.

Local anesthesia was established upon a firm basis with the demonstration of the local anesthetic properties of cocaine,—properties with which the aboriginal inhabitants of the highlands of South America were already acquainted. Dr. Roy L. Moodie has reconstructed a picture of an early surgical operation among the Incas, showing a blanket clad shaman using the cautery to make a cruciform incision in the scalp of a woman suffering from melancholia. The operator chewed a cud of coca leaves, the juice from which he could drop upon the wound if the pain became severe.

Albert Niemann, in 1858, isolated cocaine from coca leaves, while working in the laboratory of Friedrich Woehler, and both Niemann and Woehler described the numbing effect of the alkaloid upon the tongue, without recognizing the significance of this fact. Cocaine remained a curiosity for many years. In 1880, a British medical commission learnedly reported that the substance had no medical value, being at best merely a poor substitute for caffeine. That same year, von Anrep published a careful pharmacologic study of the alkaloid, in which the local anesthetic properties were hinted at, but it remained for Dr. Carl Koller actually to demonstrate its great value. Koller tried unsuccessfully to find some way to achieve local anesthesia in eye surgery, and gave up the attempt when his friend, Dr. Sigmund Freud, of psychoanalytic fame, enlisted his aid in studying the physiologic effects of cocaine taken internally. Dr. Koller noted the benumbing effect of cocaine on the tongue, as had other workers with the drug since the date of its discovery. It occurred to Koller, however, that here might be the agent for which he was seeking in connection with eye anesthesia. Experiments in Strickler's laboratory in Vienna on animals and normal human beings convinced him of the importance of his finding, and he made his first report to the German Ophthalmological Society, at Heidelberg, on September 15, 1884, through the agency of Dr. Brettauer, of Trieste. Later, he published a paper on the subject in the *Wiener Medizinische Wochenschrift*, which was immediately translated into important medical pub-

lications abroad, and within a year the new procedure was in use all over the civilized world.

Other clinical demonstrations of the value of cocaine were made by William Stewart Halsted in 1884, and by James L. Corning in 1885. Even at this early stage of the development of local anesthesia, Halsted blocked the mandibular nerve at the mandibular foramen using a cocaine solution and Corning demonstrated infiltration and spinal anesthesia. Hall and Halsted also demonstrated that the injection of a nerve trunk in any part of its course is followed by a sensory paralysis in its entire peripheral distribution.

Recent progress in the exact knowledge of local anesthetics, together with the scientific study of their toxicity and therapeutic values, has been greatly facilitated by the appointment of committees for their appraisal in both England and the United States. The field has proved a fertile one for the synthesis of chemical relatives of cocaine, and scarcely a year has passed since Koller's discovery without the announcement of a new local anesthetic agent. The most satisfactory and least toxic of all the substitutes for cocaine was prepared by Alfred Einhorn, in 1904, and introduced by H. Braun, in Germany, as novocaine, in 1905. Braun also introduced the use of suprarenin with local anesthetic agents in order to delay absorption and check bleeding. Suprarenin is a powerful vasoconstrictor and dilutions of 1:1,000,000 produce local ischemia.

The development of local anesthesia, therefore, takes us back to ancient times. In every possible manner, both chemical and physiologic, attempts were made to produce local anesthesia for the relief of operative pain by the use of cold, compression, and drugs of all kinds. Drugs were applied to the skin or mucous membranes, or they were injected; attempts were made to facilitate their absorption with electricity; yet the only method of use handed down to modern times was the application of cold. Efforts to discover an efficient chemical anesthetic failed completely and, until the discovery of the use of cocaine, local anesthesia was without tangible form.

CHAPTER III

MODERN LOCAL ANESTHETIC AGENTS

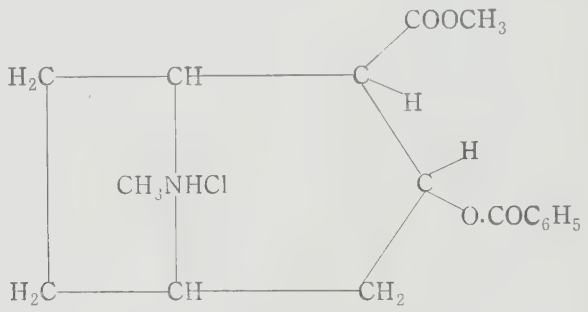
Modern local anesthesia, as distinct from general anesthesia, is produced by the application of certain chemical substances directly on the operative field, which act electively on the nerve tissues in a circumscribed area. It is based upon the possibility of temporarily inhibiting the conductivity of the sensory nerve endings without causing permanent tissue injury. This result can be obtained by certain chemical substances in two ways: either by acting directly on the nerve terminals, called terminal or infiltration anesthesia, or by acting on the nerve trunks supplying the site of operation, thereby interrupting the conduction of sensory impulses. This we call regional or conduction anesthesia. Both methods are capable of wide and effective application.

The progress of local anesthesia was greatest following the discovery of substances of specific activity. Today local anesthesia is of great importance in every branch of surgery and is employed by practically all dentists. Of the local anesthetics novocaine is the safest and most effective of the synthetic cocaine substitutes so far introduced for infiltration and conduction anesthesia. The alkaloid cocaine, for over twenty years the only local anesthetic, has gradually fallen into disuse. It is now regarded as a very dangerous drug and should never be injected beneath the skin. Although cocaine has been superseded, it was the first of the modern local anesthetics and so deserves prior consideration.

Cocaine.—The coca plant *(Erythroxylon coca Lam.)* is a shrub native to tropical South America, especially Peru and Bolivia. From time immemorial it has been prominent in the religious and political lives of the people. The interest of the scientific world was first aroused by the reports of traveling investigators, who discovered that the coca leaves were chewed by the natives of South America in order to alleviate hunger, to produce wakefulness, and to increase their physical powers of

endurance. The alkaloid cocaine was first isolated from coca leaves in 1858 by Niemann, who, in his original publication, noted that it had a peculiar numbing effect on the tongue, making the spot it had touched temporarily quite insensitive. Twenty-four years elapsed before the practical value of this observation was recognized, when Koller first published his researches.

Cocaine is a crystalline substance sparingly soluble in water. It combines readily with acids to form salts, of which the hydrochloride is the best known, and the most frequently used therapeutically. Cocaine hydrochloride is a white crystalline powder which is readily soluble in water and in alcohol. It is known chemically as benzoyl-methyl-ecgonin hydrochloride and is represented by the following formula:



Water solutions of cocaine are not very stable and are frequently contaminated by the growth of molds, which cause them to become cloudy. The more dilute the solutions the more quickly do these changes occur, but concentrated solutions are also quite subject to them. Regarding the sterilization of water solutions of cocaine, it may be said that a single rapid boiling of a small quantity of solution is not followed by a material loss of cocaine, whereas the repeated boiling of large quantities of the solution, or sterilization in a steam sterilizer, causes a diminution in the cocaine content. Long-continued boiling or autoclaving decomposes cocaine into benzoyl-ecgonin and methyl alcohol.

As stated above, successful local anesthesia made its first important advance in 1884 when Koller introduced cocaine as a modern local anesthetic. He demonstrated that by the instilla-

tion of a 2 per cent cocaine solution the eye could be made sufficiently insensitive to perform many operations without pain.

Within the next few years the use of cocaine was common in all branches of surgery. It was employed for terminal or infiltration anesthesia to anesthetize the terminal nerves in the field of operation; for regional, conduction, or block anesthesia by injecting the solution into and around nerve trunks, and finally for intraspinal anesthesia, by injecting the solution directly into the spinal canal.

The rapid progress made in local anesthesia soon met with almost insurmountable difficulties. Mild, severe, and fatal cases of cocaine poisoning were observed in great numbers. Cocaine poisoning, the habit-forming property of the drug, the instability of its solutions, as well as fluctuating supplies and high cost, led to intensive chemical study with a view to discovering other substances which would be equally efficient as local anesthetics without the serious effects of cocaine. The success of these endeavors is attested by the extremely restricted use of cocaine at the present time.

The first step in the development of the newer types of local anesthetics was the determination of the chemical structure of cocaine. This was accomplished by the researches of Liberman, Willstaetter, and particularly by Einhorn. It was found that the anesthetic property of cocaine depended upon the esterification of a basic alcohol, methyl-ecgonin, with benzoic acid, and after many years of study in this field, starting from this observation, Einhorn stated the definite principle that all esters of aromatic acids produce a greater or lesser degree of local anesthesia. Since then, acting on this principle, chemists have produced many hundreds of such esters, and in fact, the few typical substances which have been able to maintain themselves in practice belong to this class of chemical compounds.

The first attempts to supply synthetic substitutes for cocaine were confined to substances closely allied in chemical structure and as a result the eucaines were synthetically prepared by Merling and described by Vinci, in 1897. Alpha and beta eucaine were introduced into practice. The eucaines were soon practically discarded on account of their irritant action, increased toxicity, and less intense anesthesia.

A more simple class of synthetic local anesthetics was prepared by Fourneau, in 1904, of which stovaine is the most important representative. Alypin, prepared by Hoffmann and recommended by Impens in 1905, is chemically very closely related to stovaine.

By slightly varying the chemical groups contained in the molecule a large number of substances of the stovaine-alypin type were prepared. Either on account of their toxicity or their irritant action on the tissues, these substances have proved themselves not wholly suitable for local anesthesia and at the present time their use is very limited.

The next step forward in the development and progress of local anesthesia was the preparation of novocaine by Alfred Einhorn in 1904. After years of experimentation in this field he came to the conclusion that the irritating effect of the benzoic acid esters could be avoided by introducing an amido group into the aromatic nucleus and that the anesthetic effect would also be increased thereby. From a large series of alkamine esters of amido-benzoic acid which he prepared, novocaine was selected as most suitable.

Novocaine was introduced into practice by Professor H. Braun in 1905. It fulfilled his requirements for a cocaine substitute in a very exact manner. According to Braun, the cocaine substitute must first of all be less toxic than cocaine in proportion to its local anesthetic power. The agent must not cause the slightest irritation or tissue injury and must be absorbed from the place of application without any secondary effects, such as severe hyperemia, inflammation, painful infiltration or necrosis. Only when these conditions are fulfilled can we assume that the healing of wounds will not be interfered with. Further, the agent must be soluble in isotonic salt solution, and its solution must be stable and possible of sterilization by boiling. It must also be possible to combine the agent with suprarenin.

Since the introduction of novocaine an extremely large number of investigators have demonstrated the unique value of this local anesthetic. The Committee on Synthetic Drugs of the National Research Council included novocaine among the three most necessary synthetic drugs. The rapid extension of its

employment and the fact that twenty-one years after its introduction it has found its way into every important dental clinic and has, in general use, practically superseded all other soluble local anesthetics for infiltration and conduction anesthesia is a sufficient testimonial of its value. This obvious conclusion is confirmed by strict scientific comparisons of all the proposed local anesthetics by authorities who have published their results from time to time.

A number of other types of substances have been investigated as local anesthetics: holocaine, a phenetidine derivative used in ophthalmology; chloretone, a number of phenols, vanillin, saponin, quinine and many other substances.

Apothesine was introduced into dentistry by Woodbridge in 1918. During the same year, Macht called attention to the anesthetic properties of benzyl alcohol. Hirschfelder, in 1920, investigated the action of other aromatic alcohols and states that out of this series saligenin or salicyl alcohol is the best and least irritating. Butyn was recommended for clinical trial in 1921. The most recent addition to the list of synthetic local anesthetics was the introduction of a substance called tutocaine, in 1924.

A group of benzoic acid derivatives, insoluble in water, namely, the alkyl esters of amido-oxy-benzoic acids and the alkyl esters of amido-benzoic acids, have also been described, which possess more or less strong anesthetizing properties when in direct contact with exposed nerve ends. They contain no basic group which is capable of forming neutral water-soluble salts. Owing to their insolubility in water and tissue fluids they cannot penetrate the intact skin or mucous membrane, and they cannot be used in surgery where a water solution of the drug is to be injected into the tissues. The use of these compounds has therefore been limited to direct application to tooth sockets, wounds, ulcers, burns, etc., where nerve ends may be exposed. The amido-oxy-benzoic acid esters were developed by Einhorn, who prepared more than forty different esters, all of which showed anesthetic properties. From this series orthoform, the methyl ester of m-amido-p-oxy-benzoic acid, was introduced into practice. Of the p-amido-benzoic acid series anesthesin or parathesin, the ethyl ester, is the best known. Many other esters

have been made and their possible number is limited only by the number of alcohols which can be esterified.

Novocaine and other cocaine substitutes mentioned above will be discussed in special chapters. Suprarenin is a vasoconstricting agent and has no anesthetic action. When added to a local anesthetic solution it causes the anesthesia to become more pronounced and of longer duration. It also reduces or prevents hemorrhage and lessens the rate of absorption.

CHAPTER IV

LOCAL NOVOCAINE ANESTHESIA VERSUS GENERAL ANESTHESIA

The prevention of pain is a professional duty we owe to our patients; it is a moral obligation and the operator who heedlessly inflicts pain injures his professional standing and outrages his own moral sense and conscience. Modern dental science has been successful in eliminating pain and the fear of pain by the use of novocaine anesthesia.

The general anesthetics are chemical substances, known as hypnotics, which act directly on the brain, inhibiting its function while leaving the sympathetic centers of respiration and circulation comparatively unaffected. Ether, ethyl chloride, chloroform, nitrous oxide, and other substances, when properly administered, produce a sensory depression and general unconsciousness by direct action on the central nervous system. This is called narcosis or general anesthesia.

The local anesthetics are chemical substances which act directly on the sensory nerve endings or nerve trunks in a circumscribed area. They do not depress the central nervous system.

Anesthesia may be accomplished in three ways:

1. By depriving the patient of consciousness by the administration of a general anesthetic without in any way influencing his sensory nerve endings or nerve trunks (general anesthesia).

2. By temporarily inhibiting the conductivity of the sensory nerve endings by local infiltration of novocaine solution directly in the part to be operated upon (terminal or infiltration anesthesia).

3. By temporarily depriving the nerve trunks supplying the site of the operation of their conductivity, thereby interrupting the conduction of sensory impulses (conduction or block anesthesia).

A satisfactory anesthesia must be (1) painless, (2) thorough, and (3) devoid of danger.

It may be stated without reservation that local anesthesia is much safer than general anesthesia. The disadvantages of general anesthesia lie in the fact that it affects the entire organism and not a circumscribed portion; that a certain number of fatalities are inevitable; that its induction is usually followed by unpleasant after-effects, and that it requires trained assistants and considerable technical detail for administration.

The trend in general surgery is away from general anesthesia. Dr. Emil Mayer's Committee on Local Anesthesia states that local anesthesia is the method of choice by practically all American rhinologists, and for throat operations the majority operate under local anesthesia and declare themselves to be entirely content with it. There is less hemorrhage, far greater safety, and the dangers of toxicity compare favorably in the use of the local anesthetic in preference to any general anesthetic.

Braun states that in 50 per cent of all surgical operations local novocaine anesthesia can successfully replace general anesthesia.

Professor Finsterer, Chief of the Surgical Clinic in Vienna, reports 500 cases of gastroenterostomy under novocaine anesthesia. Operations for the removal of goiter, hernias, hemorrhoids and appendectomies are preferably done today under novocaine. There is less danger to life under local than under general anesthesia. Cardiac and pulmonary cases, diseases of the kidneys and blood vessels with their increased blood pressure, sufferers from exophthalmic goiter, anemias, leucemias, diabetes, weakly children and certain physical types, such as obese women and short stocky men, involve a greater risk under general anesthesia than they do under local anesthesia. Pulmonary abscesses and postoperative pneumonias are concomitants of general and not of local anesthesia.

It is impossible effectively to cope with the mishaps of general anesthesia in the office of the unassisted general practitioner, since it is well-nigh impossible for the operator to administer a general anesthetic and to operate as well. Moreover, the stage of excitement usually accompanying the production of general anesthesia requires the services of trained assistants—aid that is not usually available in the office of the general practitioner. Patients, during this stage, have killed themselves by

jumping from open windows. Additionally, like assistance should be forthcoming if, as is likely to occur when general anesthesia is being induced, heart inefficiency or failure of respiration supervenes. Safeguards, paraphernalia, and trained assistants are required for such emergencies and again these are not forthcoming in general office practice.

Extraction, as conceived today, is not confined merely to the removal of a tooth from its socket. It takes into account the removal of pathologic tissue from the floor and sides of the socket, the trimming of the alveolar process, and in many cases the making of a flap and surgical removal of roots in cases of fracture of a tooth. Such procedures require time and cannot be done hurriedly. The mouth fills up with blood and requires constant sponging to keep it dry and to establish a continuously visible field of operation. Nitrous oxide is an evanescent anesthetic and does not readily lend itself for prolonged anesthesia. The operator must usually work hurriedly, and while he may perform the operation to the satisfaction of the patient who craves nothing more than the removal of the tooth, he cannot accomplish this to his own satisfaction.

Nitrous oxide has a mortality record. Mayer states that the nitrous oxide and oxygen combination, looked on by many as absolutely safe, has a record of deaths that destroys that assuredness. One observer reported 37 deaths from this "safest anesthetic."

McCormick, in 1923, collated 163 deaths in the United States due to nitrous oxide. Salzer and Stewart have recently collected statistics which give a mortality rate from general anesthesia of 1 in 600. The margin of safety with nitrous oxide is entirely too narrow for it to retain a reputation as the "safest anesthetic in the world," and one should not attempt to induce nitrous oxide oxygen anesthesia unless he is competent and equipped to handle any kind of an emergency which may arise.

Fischer states that in a practice comprising over 30,000 dental operations he has not had a serious case of intoxication after the injection of novocaine.

Patients are learning that when operated upon under local anesthesia they are spared the discomforts or disasters that attend the use of a general anesthetic. Most people prefer to

remain awake and conscious during an operation in which they will have no pain.

By the adoption of local anesthesia the dental surgeon safeguards the patient against crude, rough, and clumsy work on the part of the operator, the corollary of which is that local anesthesia exerts a refining influence upon the operator's technic, so that he develops precision, neatness, and skill and learns a wholesome respect for tissues, with the result that operative trauma and postoperative pain are reduced to a minimum. With local anesthesia there is by no means the risk that attends prolonged general anesthesia, time is not a factor, and therefore more careful attention can be devoted to details of technic.

A not unimportant advantage of local anesthesia is its safety. The general surgeon recognizes that certain operations may be performed under local novocaine anesthesia with perfect safety upon patients who would have died under general anesthesia. In this category belong: first, those patients of advanced age; second, those with handicapped cardiac, respiratory, hepatic, or renal organs and, third, those with altered metabolism, toxemia, or acidosis. Bartlett states that by using novocaine with correct technic one may be practically sure that no immediate danger to life is involved. Of the drugs employed, novocaine is thoroughly effective and the safest of all the local anesthetics available today. Not only is novocaine the safest local anesthetic, but it is generally acknowledged to be the safest of all known anesthetics. If properly administered, novocaine may be used almost *ad libitum,* for the extended experience of many general surgeons shows that in the case of the ordinary adult 200, 300, or even 500 c.c. of a 0.5 per cent solution is safe.

Local anesthesia offers an additional and important advantage over general anesthesia, in that local anesthetics can be very readily applied and require no lengthy preparation either on the part of the operator or of the patient. This is an extremely valuable feature, especially for ambulatory dental practice, in a big city as well as in the country, in the dentist's office as well as at the patient's home. The production of general anesthesia under difficult conditions or in unsuitable surroundings offers

infinitely greater disadvantages, and its final success is incomparably more hazardous than that which can be obtained in dental operations under local anesthesia by a skilled hand at almost any time, in any place, and on almost any patient. To be sure, the dentist must have sufficient experience to cope with any difficulties that may arise in any case; he must be a master in painless manipulation, and be fully proficient in the technic of local injections; he must know exactly the pharmacologic and physiologic effects of his injection solution, and, above all, he must be able to diagnose the general condition of each patient in order to treat him according to individual requirements. There is no doubt that the behavior of the individual organism in absorbing an injected solution must largely determine the operator's method of procedure. The dentist can inject a smaller quantity of solution in greatly anemic or tuberculous patients, and reduce the dose of the suprarenin, which is dangerous for the heart, without jeopardizing the success of his operation. Such patients will often tolerate only very superficial general anesthesia, and even then they are in constant danger, and pain is only partially abolished. The application of local anesthesia in such cases is far more advisable, since it guarantees perfect success and invariably meets with the patient's full approbation.

Medicolegally the dental surgeon is protected if he employs local novocaine anesthesia. Suppose, for example, the patient demands a general anesthetic and the operator finds some pathologic condition which contraindicates its use. If the operator administers the general anesthetic and the result is death he is legally responsible and would be held for incompetency and criminal neglect.

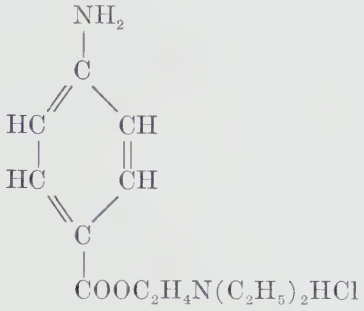
General anesthesia is unnecessary in operations in the oral cavity except in acute infections about the mouth or teeth when the removal of a tooth can be rapidly accomplished or an alveolar process incised and pus evacuated; in cases of trismus due to an infected third molar; and for opening large facial or cervical swellings where there is distinct pointing of the abscess; also in very nervous patients and in children where operative procedures can be readily accomplished under a brief anesthesia.

The author agrees with Harris in the conclusion that it is no longer necessary to rob the patient of his senses and expose him to the dangers of narcosis in order to extract painlessly one or more teeth. The operator, with novocaine at his command, does not have to deny himself the advantages of a bloodless field and the patient's cooperation in the performance of difficult operations which require vision and skill exceeded in no other branch of surgery.

CHAPTER V

NOVOCAINE

This preparation is known chemically as the monohydrochloride of p-amino-benzoyl-diethyl-amino-ethanol and has the graphic formula:



While possessing the same power to anesthetize, novocaine is far less toxic than cocaine or any of its substitutes. Novocaine is a synthetic chemical. Cocaine is an alkaloid obtained from coca leaves. These two compounds are entirely different, each possessing an entirely different arrangement in the chemical make-up of its molecules. Novocaine is not related chemically to cocaine.

Novocaine is a white crystalline substance which melts at 156° C. It can be heated without decomposition to 120° C. The dry novocaine crystals when placed in sealed resistant glass ampules can be sterilized by autoclaving for thirty minutes at 15 pounds of steam pressure without decomposition. Novocaine dissolves in equal parts of cold water, the solution giving a neutral reaction. Caustic alkalies and their carbonates precipitate the free base from aqueous solution in the form of an almost colorless oil which soon solidifies to a crystalline mass. Alkaloidal reagents, such as potassium mercuric iodide, picric acid, potassium iodide, and iodine solutions produce precipitates even in very dilute aqueous solutions.

Novocaine has no irritating qualities when applied in concentrated solution (20 per cent) upon fresh wounds. When instilled

into the eye it causes no disturbance and even when the pure drug is sprinkled on the cornea it causes only slight irritation of short duration. It causes no mydriasis, no disturbance of the accommodation, and no increase of intraocular pressure.

Novocaine may be combined with suprarenin, a synthetic product identical with the active principle of the adrenal gland, the combination producing rapid and prolonged anesthesia with temporary ischemia of the anesthetized tissues.

Novocaine does not have habit-forming properties, and its sale and distribution is not governed by the provisions of the Harrison Anti-Narcotic Act.

Water solutions of novocaine can be sterilized by boiling without deterioration, and if kept sterile and out of contact with air they remain clear, water-white, and otherwise unchanged indefinitely. There is no deterioration in anesthetic properties of properly stored sterile water solutions of novocaine, and there is no increase in toxicity. Sterile water solutions of novocaine are therefore stable.

For the preparation and sterilization of novocaine solutions containing suprarenin, nonalkaline glass flasks or porcelain novocaine-dissolving cups should be used. Ringer's solution or 0.6 per cent sodium chloride solution prepared with chemically pure sodium chloride should be employed as the vehicle. After the addition of the novocaine-suprarenin tablets the solution should not be boiled for more than from one to three minutes. The solution should not be kept for any length of time, but should be utilized as soon as possible. The development of a faint pinkish-brown or light brown color does not increase the toxicity of the solution nor appreciably impair its activity. The discoloration of novocaine-suprarenin solutions when boiled and allowed to stand exposed to the air is due to the oxidation of the suprarenin. Any water solution of epinephrin, either the natural or synthetic, when boiled in the presence of air will develop a pink or brownish-pink color on standing.

Novocaine solutions which are improperly sterilized and stored are not stable and should never be used as a local anesthetic. They become cloudy, show a sediment, and develop a yellow or brown color due to the progressive growth of molds and bacteria. If such a solution were used as a local anesthetic

it would undoubtedly cause severe tissue damage at the site of the injection and might possibly set up a general infection that would kill the patient. Properly prepared sterile novocaine solutions are fit for use so long as they remain sterile and show no appreciable change in color.

The infiltration of tissues with novocaine solution (0.5 per cent to 2 per cent) causes no vasoconstriction or vasodilatation and leaves no after-effects upon the tissues. Novocaine solutions, when injected subcutaneously, exert the same action upon the peripheral sensory nerves as cocaine and when combined with suprarenin they produce an equally pronounced and lasting anesthesia.

Experimentally there is no drug used in medicine which has been subjected to more exhaustive or more critical pharmacologic investigation. Foremost among the investigators may be mentioned Biberfeld, LeBrocq, Piquand and Dreyfus, Frankfurther and Hirschfeld, Hatcher and Eggleston, Roth, Meeker and Frazer, and Hooper and Becker. All are agreed that novocaine is less toxic than cocaine or any of its substitutes.

For a given animal, all experimental factors being equal, the great difference in the toxicity of novocaine and cocaine is caused by the difference in the rate of elimination of the two drugs. Novocaine is rapidly eliminated by destruction in the liver; cocaine is slowly excreted, mainly through the urine. Eggleston and Hatcher, in 1919, demonstrated that by slow or repeated intravenous injection the cat's liver can detoxify or destroy novocaine at the rate of at least one rapidly injected fatal vein dose every twenty minutes. Cocaine, on the other hand, is eliminated so slowly that the animal soon develops symptoms of cumulation, as shown by the increasing severity of the symptoms and ultimate death of the animal.

According to Eggleston and Hatcher, the phenomena of acute intoxication after the rapid intravenous injection of a toxic dose of novocaine in the cat are stimulation of respiration and an abrupt fall in blood pressure, the heart rate varying but usually being slowed. Within five minutes the animal may be normal again. The fall in blood pressure is due to a weakening of the heart and not to any immediate vasodilatation. Animals that

are killed by the dose, die of paralysis of the heart and respiratory center.

The toxicity of novocaine is greatest when a concentrated solution is injected rapidly into the vein, in which case a dose of 40 mg. per kilogram of body weight is fatal to the cat; when administered slowly, 408 mg. per kilogram may be administered with only temporary disturbance. The results of their experiments show that the amount of novocaine required by intravenous injection to cause death varies very widely with the rate of administration and that enormous amounts can be injected slowly without causing death.

Roth, in 1917, studied the relative toxicity of cocaine and novocaine for various animals when given subcutaneously. The novocaine was administered in 20 per cent solution and the cocaine in either a 5 or 10 per cent solution. He shows that novocaine is one-tenth as toxic as cocaine for rats and guinea pigs and one-fifth as toxic as cocaine for mice and rabbits. Also, when cocaine and novocaine in cakes are fed to mice, cocaine is fifty times more toxic than novocaine.

The absorption of novocaine from the subcutaneous tissues, as indicated by the time of onset of the toxic symptoms, may be delayed by administering the drug in hypotonic solution or by the simultaneous administration of suprarenin.

A number of attempts have been made to simplify the clinical use of novocaine. Accordingly, Braun introduced novocaine tablets of definite weight with and without combination with suprarenin. The tablets have come into extended use in dentistry because they are convenient for making a fresh novocaine solution at the time of operation. The preparation of novocaine solution from the powder, with suprarenin added in drops, is not sufficiently reliable and uniformly practicable in daily practice. A tablet added to a given amount of vehicle prepares a solution with a definite percentage of novocaine and suprarenin.

The tablets commonly employed are:

N. S.* Tablet "E"

℞ Novocaine ---------- 0.02 gm. (⅓ grain)
Suprarenin ---------- 0.00005 gm. ($\frac{1}{1300}$ grain = ⅚ minim 1:1000 solution).

*Novocaine suprarenin.

One tablet dissolved in 2 c.c. (32 minims) physiologic salt or Ringer's solution prepares a 1 per cent novocaine solution containing suprarenin 1:40,000.

One tablet dissolved in 1 c.c. (16 minims) physiologic salt or Ringer's solution prepares a 2 per cent novocaine solution containing suprarenin 1:20,000.

N. S.* Tablet "T"

℞ Novocaine ..... 0.02 gm. (⅓ grain)
Suprarenin ..... 0.00002 gm. ($\frac{1}{3200}$ grain = ⅓ minim 1:1000 solution)

One tablet dissolved in 2 c.c. (32 minims) physiologic salt or Ringer's solution prepares a 1 per cent novocaine solution containing suprarenin 1:100,000.

One tablet dissolved in 1 c.c. (16 minims) physiologic salt or Ringer's solution prepares a 2 per cent novocaine solution containing suprarenin 1:50,000.

N. S.* Tablet "H"

℞ Novocaine ..... 0.06 gm. (1 grain)
Suprarenin ..... 0.00006 gm. ($\frac{1}{1200}$ grain = 1 min. 1:1000 solution). (three times the strength of the "T" tablet.)

One tablet dissolved in 6 c.c. (96 minims) physiologic salt or Ringer's solution prepares a 1 per cent novocaine solution containing suprarenin 1:100,000.

One tablet dissolved in 3 c.c. (48 minims) physiologic salt or Ringer's solution prepares a 2 per cent novocaine solution containing suprarenin 1:50,000.

N. S.* Pluglets

℞ Novocaine ..... 0.01 gm. (⅙ grain)
Suprarenin ..... 0.0002 gm. ($\frac{1}{320}$ grain)

To be used for pressure anesthesia in the removal of dental pulp.

The tachycardia and other minor symptoms of excitation which occur at times immediately after the injection of novo-

*Novocaine suprarenin.

caine solution are usually caused by the suprarenin. The tablet "T" prepares a solution containing sufficient suprarenin for all practical purposes. Its use is rapidly growing in favor because it contains only two-fifths of the amount of suprarenin contained in tablet "E". It should be remembered that suprarenin when injected intravenously into experimental animals is approximately 500 times more toxic than novocaine.

A novocaine dissolver has been devised especially for the purpose of preparing sterile solutions of novocaine and novocaine suprarenin for immediate use. This little cup is made of chemical porcelain and is graduated in cubic centimeters. It is available in two sizes with capacities of 3 c.c and 10 c.c. It is provided with a convenient metal stand and handle which appreciably simplifies its use. The required quantity of physiologic salt, Ringer's solution, or sterile water, as the case may be, is poured into the porcelain cup. It is then sterilized by boiling, and thereupon the necessary number of tablets are added. The solution is brought to a boil for the second time, because there is a possibility of tablets occasionally containing bacteria.

The painless and successful infiltration of tissues with a local anesthetic solution is dependent, to a great extent, upon the isotonicity of that solution with the tissue cells and fluids.

The cells of the tissues consist of an envelope of semipermeable material inclosing a solution of various crystalloids and colloids, which are in a state of equilibrium with one another. This equilibrium is readily altered by various influences that may act on the cell, and the resulting changes manifest themselves outwardly by alterations in the shape and volume of the cell. If the fluids within and without the cell are of the same consistency, and if their percentage in salts is the same, then isotonia or equal tension is present. If a solution is injected which does not conform with the amount of salts in the tissue, the cells are either contracted or distended. The absorption of the injected solution is retarded and a pathologic condition ensues. The power which regulates this interchange is called osmotic tension.

Physiologically speaking an isotonic solution is a chemically indifferent solution possessing the same osmotic tension as the

cells and tissue fluids. Normal physiologic salt solution (0.6 per cent sodium chloride) is an example. Fluids of greater or less osmotic tension cause pain by drawing water from the tissues or by causing them to swell. By the use of isotonic physiologic salt solution as a vehicle for novocaine, the tissues are not injured and recover promptly. The salt solution has no physical effect itself but allows the drug to act alone.

Guido Fischer states that the question of isotonicity cannot be emphasized too strongly. The efficacy of the solution depends upon its proper composition, perfect isotonia, and sterilization before injection. The isotonicity of a solution and its optimum rapidity of absorption are assured by the addition of Ringer's solution. Sodium chloride solution alone is by no means cognate to the cell nor strictly "physiologic" because it lacks important constituents which the cell requires for normal metabolism.

For over ten years Fischer has advocated Ringer's solution as the vehicle for novocaine-suprarenin, and has noted in all cases an improvement both in the anesthetic action and in the after-effects as compared with the use of sodium chloride solution alone. In severe purulent conditions, in which the sodium chloride solution produces edema, after-pain, and disturbances in the healing process, all secondary effects are surprisingly trivial or entirely absent after using Ringer's solution.

The Ringer's solution is best prepared fresh each time immediately before using. This can readily be accomplished by employing the following commercial tablet:

Ringer's Solution Tablet (Fischer)

℞ Sodium Chloride.....0.05 Gram
Calcium Chloride.....0.004 "
Potassium Chloride.....0.002 "

Ringer's solution is prepared by dissolving 1 tablet in 10 c.c. of distilled water.

A hypotonic solution is one whose osmotic pressure is less than that of the cells and tissue fluids. A hypotonic sodium chloride solution and even distilled water have been used quite extensively as a vehicle for novocaine. Distilled water in itself has a definite local anesthetic effect when injected into the skin.

Halsted, in 1885, was the first to show that the skin can be completely anesthetized by cutaneous injection of distilled water and at times he employed this method of local anesthesia in minor operations requiring skin incisions. The method was later thoroughly studied by Liebreich, Schleich, and Braun. The injection of distilled water into the skin is quite painful, and its consequent anesthesia is imperfect and of short duration. However, when novocaine is added to the distilled water, anesthesia follows so quickly that the injection, unless the fluid be injected too rapidly, is scarcely perceptible. Schleich believed that there must be a solution of such concentration between pure water and a 0.6 per cent salt solution which would not provoke pain upon injection; but on account of similarity to pure water it would later produce anesthesia. As the result of his experiments he exclusively used a 0.2 per cent salt solution as the vehicle. Allen states that the employment of a 0.2 per cent solution of sodium chloride for a vehicle, as recommended by Schleich, yields good results clinically in the healing of wounds.

A hypertonic solution is one whose osmotic tension exceeds that of the blood plasma or tissue fluids. It is more concentrated than an isotonic solution. It is created when a stock Ringer's solution or physiologic salt solution is boiled for a prolonged period for sterilization. When injected it rapidly extracts water from the tissue cells producing cellular contraction and dehydration. The injection is followed by postoperative pain, irritation, and damage to the tissues. The accidental use of concentrated salt solution (10 to 25 per cent) will usually lead to extensive tissue necrosis, sloughs, and gangrene. If such a solution is injected into a nerve trunk permanent paralysis may result.

Postoperative complications, such as severe hyperemia, inflammation, painful infiltration, sloughs or necroses are either the result of infection, the addition of an excessive amount of epinephrin, or the use of hypertonic salt solution as the vehicle. These complications are not caused by novocaine in itself. It should not be overlooked that the ischemia caused by epinephrin is intensified by novocaine and for this reason the amount of epinephrin used should be cut down to a minimum. It should be the rule not to inject epinephrin into tissues in which the

vitality is already reduced, inasmuch as they recover very slowly if at all from the effects of this agent.

Failures may not be due to the solution. The solution, glassware, syringe, needles, and field of operation must be absolutely sterile. The solution must be correctly prepared; the anatomy and pathology of the field of operation must be given due consideration and, finally, the technic of the injection must be controlled by the conditions presented and by the physical constitution of the patient.

The question of having ampules made by the manufacturer containing ready prepared solution of the synthetic local anesthetics has been favorably considered by the Committee of the American Medical Association on Local Anesthetics. Ready-to-use solutions of novocaine with suprarenin corresponding in strength with the solutions prepared from the N. S. Tablets "E" and "T" are now available in 1, 3, and 6 c.c. hermetically sealed nonalkaline crystal-clear resistant glass ampules. These water-clear solutions are sterile, isotonic, stable, and very efficient. These ampuled solutions are very popular because they afford protection against avoidable accidents and mistakes in the preparation and sterilization of novocaine solutions; take the place of old stock solutions which may have become contaminated or hypertonic, and are a great convenience to the oral surgeon.

These solutions are manufactured in an exact manner and have been thoroughly tested for sterility and stability. They remain sterile indefinitely in the intact ampule. Some of the ampules are over four years old. The solutions are still water-clear, give as satisfactory anesthesia as when they were first prepared, and do not damage the tissues when injected.

Fischer states that the closing of ampules with small rubber discs is to be discountenanced, because the sulphur compounds in rubber imperil the stability of a solution containing suprarenin. This has been shown by the decomposition of suprarenin in bottles closed with rubber stoppers; since these have been substituted with cork or glass stoppers, suprarenin solutions are more uniform and stable.

He further states that the ampules must be kept as aseptic as every other instrument used for injection. The unbroken am-

pule contains a sterile solution, yet its outer surface is by no means sterile. It passes through many hands, is packed in ordinary cotton, and should therefore not be used without having been previously sterilized. The operator is cautioned not to nick the neck of the ampule with an unsterile file. This measure invites sepsis, and is absolutely unnecessary, even dangerous. From the unsterile file, infectious bacteria may be introduced into the sterile solution after the neck is broken. Ampules are best sterilized by carefully washing some half dozen in a weak solution of carbolic acid or lysoform, drying and preserving them in a covered glass jar or tray containing 70 per cent alcohol. When needed, an ampule is taken from the alcohol with sterile pincers and laid between sterile gauze or cotton; the neck is broken in the gauze while inverting the ampule—an easy procedure; the mouth is carefully exposed, and the contents are drawn out through an iridio-platinum hypodermic needle which has previously been sterilized by passing through an alcohol flame.

The Committee of the American Medical Association on Local Anesthetics has stated that novocaine is the safest of all local anesthetics now in general use, and that measured quantities of a known strength solution should be prepared at the time of injection, or sterile solution in ampules employed. Attention is called to the fact that it is dangerous to use more than one local anesthetic at a given time. It is unwise to administer a local anesthetic and then follow it immediately with a general anesthetic. Also, large doses of epinephrin are proved to be unsafe in conjunction with a local anesthetic.

In the domain of stomatology, stock solutions of unknown strength and composition are frequently used. Insufficient attention is given to proper care and sterilization of needles and syringes as well as to making the solution and to the preparation of the patient and the field of operation.

There are some concerns that prey upon the untutored practitioner who has failed to master the technic of local anesthesia. They sell to the young dentist, or surgeon, local anesthetics whose composition is not definitely known and the action of these drugs is doubtful to say the least. A note of warning is

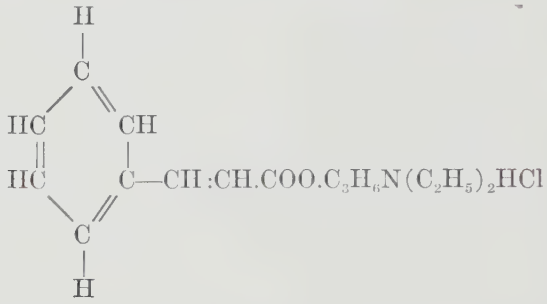
sounded against trade houses ever ready to give the uninitiated practitioner "something just as good."

In conclusion, it is conservative to say that novocaine is the most commendable of all the local anesthetics known at the present time for infiltration and conduction anesthesia. Its low toxicity permits large doses to be used without inconvenience to the patient; it produces a very satisfactory anesthesia; it is non-irritant; it does not cause any local vasodilatation when injected subcutaneously, and it may be combined with suprarenin.

CHAPTER VI

APOTHESINE, BUTYN, AND TUTOCAINE

Apothesine.—This synthetic cocaine substitute was prepared by Wildman and Thorp in 1916. It is essentially a combination of cinnamic acid and propyl alcohol and is chemically designated as the hydrochloride of gamma-diethyl-amino-propyl-cinnamate with the graphic formula:



It occurs in the form of small white crystals having a melting point of 137° C. It is readily soluble in water and alcohol and slightly soluble in acetone and ether. The solution in distilled water is neutral to litmus and may be boiled without decomposition. Aqueous solutions of apothesine produce precipitates with the alkaline hydroxides and their carbonates and with the usual alkaloidal reagents.

Apothesine is effective for infiltration anesthesia, but relatively inefficient when applied to mucous membranes. When injected, it is slower in action than novocaine and requires somewhat stronger solutions. Eggleston and Hatcher, in 1919, by rapid intravenous injection in cats, found apothesine less toxic than cocaine but twice as toxic as novocaine. In 1924, Hooper and Becker obtained similar results by employing the albino rat. Sollman, in 1918, demonstrated that the anesthetic efficiency for this drug when injected hypodermically is unmistakably lower than that of cocaine, being at best one-half. The series also showed that the potency of apothesine was never greater than

novocaine and averaged considerably below it. Apothesine was not accepted by the Council on Pharmacy and Chemistry until 1924, on account of the fact that the drug was advertised to be as potent as cocaine and to have a low toxicity.

In 1921, the Committee on Local Anesthetics in Ophthalmic Work of the American Medical Association reported that 25 per cent of the answers indicated that apothesine is next to useless as an instillation, and not as satisfactory as either cocaine or novocaine in infiltration anesthesia.

Mook, in 1920, reported two cases of apothesine dermatitis.

Cases of nonfatal apothesine intoxication have been indicated by the testimony of various observers cited by the Committee of the Section of Laryngology, Otology, and Rhinology of the American Medical Association. The following is quoted from the Committee report of 1920:

"Effects from apothesine 1 per cent, neurotic woman, pulse became very feeble, convulsions, unconscious two hours (Lewis).

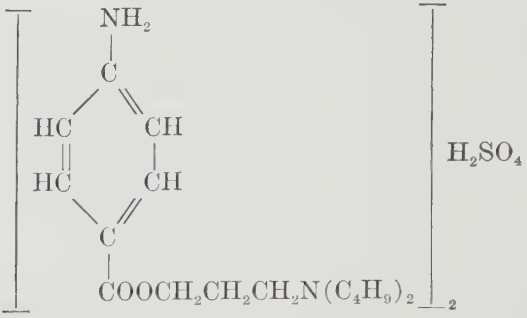
"Apothesine injection 2 per cent, complete collapse, unconsciousness, intermittent contractions of all muscles, Cheyne-Stokes breathing for one hour (Lockhard).

"Tendency to syncope in few cases (Royce).

"Paleness, increased heart action, three cases became unconscious for two minutes, two cases vomited (Campbell)."

At least six deaths have been reported following the use of apothesine, the first by Ireland, in 1920, the second, by Duboff a few months later, and four by Mayer, in 1924. Mayer states that two members of his committee reported that apothesine caused the most frequent complaint among those who reported to them, especially because of sloughing that followed its use.

Butyn.—This synthetic local anesthetic was prepared by Kamm, Adams, and Volweiler in 1920, and recommended for clinical trial by the Council on Pharmacy and Chemistry of the American Medical Association in 1921. It was proposed as a substitute for cocaine, particularly in surface anesthesia as for the eye, nose, and throat. It is known chemically as para-amino-benzoyl-gamma-dinormal-butyl-aminopropanol sulphate and has the following structural formula:



It is a colorless, odorless solid which melts at 98° to 100° C. It dissolves slowly in cold water, but rapidly in hot water. It is very soluble in warm alcohol and in acetone. Its water solution can be heated to boiling without decomposition. It can be combined with suprarenin. Butyn is precipitated from aqueous solution by the alkali hydroxides, carbonates, and bicarbonates.

Butyn is a homologue of novocaine. Both are alkamine esters of para-amino-benzoic acid. The alkamine group of novocaine contains two ethyl radicals attached to ethanol while that of butyn contains two butyl radicals attached to propanol.

From the chemical structure of the two compounds one would expect butyn to be much more toxic than novocaine, as it is well known that the toxicity of the alcohols increases with the size of the molecules. Bonar and Sollman in an investigation supported by a grant from the American Medical Association, have shown butyn to be even somewhat more toxic than cocaine. They found it to be two and one-fourth times more toxic than cocaine when injected subcutaneously into albino rats, and the lethal dose for the cat and rabbit by rapid intravenous injection was about equal to that of cocaine. Professor Hatcher, of Cornell Medical School, carried out toxicity experiments in cats and concludes that the fatal dose for the cat by rapid intravenous injection is approximately 15 mg. per kilogram body weight; that much smaller doses cause marked respiratory disturbance, and that there is a marked convulsive action with doses as small as 5 mg. per kilogram. He further states that the elimination of the drug appears to be practically complete in one hour and a half. In 1919, Eggleston and Hatcher stated that novocaine is eliminated at the rate of at least one rapidly injected fatal vein dose every twenty minutes. Holocaine, an eye anesthetic, is

apparently destroyed a little less rapidly, one fatal vein dose requiring about half an hour, while cocaine is not destroyed at the rate of more than about one fatal vein dose per hour, if as rapidly as that, and the rate of its destruction apparently decreases progressively.

As regards the anesthetic activity of butyn, Bonar and Sollman conclude that it produces complete anesthesia on surface application to mucous membranes, such as the conjunctiva, in concentrations about one-half those of cocaine, one-tenth those of procaine, or about the same as holocaine, and that the compound may hold promise of usefulness for anesthesia of intact mucous membranes, especially in the eye.

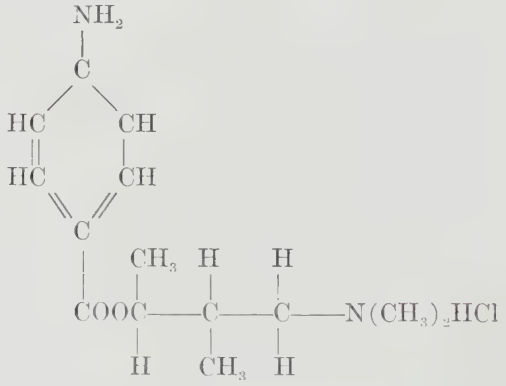
Nielsen and Higgins, in 1923, confirmed the work of Bonar and Sollman in regard to the toxicity of butyn. They stated that when given subcutaneously it is twice as toxic in rats, three and two-thirds times as toxic in rabbits, approximately equal in toxicity in cats, but slightly less toxic in dogs than cocaine. Introduced directly into the blood stream in rabbits and cats and orally to cats, butyn is about equal in toxicity to cocaine. In 1925, Higgins stated that butyn is five times more toxic than novocaine when injected intravenously into rabbits and approximately ten times more toxic when injected subcutaneously in all animals tested. He also stated that for rabbits cocaine and butyn are more toxic when injected into the neck region than when injected on the side close to the hind legs. In the case of novocaine, the toxicity remains the same regardless of where the drug is injected.

Bulson and also Beaumont, in 1922, advocated the use of butyn as a substitute for cocaine in ophthalmology. The following year Kerr stated that butyn cannot be used exactly as cocaine. Quite a small quantity of the solid laid on a sty produced white sloughing of the conjunctival surface, and violent chemosis followed although it was washed off in a few seconds. Ferguson, in 1923, stated that in both nose and throat work he has found butyn inferior to cocaine. In 1924, Thomson reported four cases in which butyn did not give satisfaction, in fact untoward effects were encountered. Thomson sees nothing but disadvantages and dangers in using butyn. Greenwood in the same year reported a case of butyn dermatitis.

The Mayer Committee for the study of the toxic effects of local anesthetics in 1924, reported five deaths following the clinical use of butyn alone or in combination with cocaine. Two of the deaths followed within a few minutes after the application of a 5 per cent solution of butyn to the nose. The Committee state that butyn should not be injected and for topical application, concentrations not greater than 2 per cent should be used.

The use of butyn for injection anesthesia or for special anesthesia in oral surgery is contraindicated because its toxicity is materially greater than that of cocaine.

Tutocaine.—This synthetic compound is another homologue of novocaine. It was prepared in Germany by Schulemann, in 1922. Tutocaine is derived from secondary butyl alcohol and is known chemically as the monohydrochloride of p-amino-benzoyl-dimethyl-amino-B-methyl-isobutanol and has the graphic formula:



It is a white crystalline powder which melts between 213° and 215° C. It is readily soluble in water. The solution in distilled water is neutral to litmus and may be boiled without decomposition. It is compatible with suprarenin.

Tutocaine was tested pharmacologically by Schulemann in 1924, by Copeland in 1924 and 1925, by Watson-Williams and by Hirsch in 1925. Copeland, of the Pharmacologic Laboratory, Cambridge, England, compared tutocaine with novocaine, cocaine, and butyn and found that by subcutaneous injection the toxicity of tutocaine for rabbits is double that of novocaine, and for guinea pigs and mice it is two to three times as toxic. By

rapid intravenous injection of 1 per cent solutions in rabbits the toxicity of tutocaine is four times that of novocaine and nearly approximates that of cocaine and butyn.

Copeland also compared the anesthetic action of cocaine, tutocaine, psicaine and novocaine quantitatively on the anterior crural nerve (sensory fibers) and the vagus nerve (cardiac inhibitory fibers). The results are given in Table III:

TABLE III

	COCAINE HYDROCHLORIDE	TUTOCAINE	NOVOCAINE	PSICAINE
Vagus nerve:	0.1%	0.1%	0.1%	0.1%
Cardiac fibers	12	10	0	5–8
Anterior crural nerve:	0.05%	0.05%	0.05%	0.05%
Sensory fibers	15–20	5–8	15–20	0

(Figures refer to the duration of complete loss of conductivity in minutes.)

Table III shows that novocaine has a strong affinity for sensory fibers and relatively little action on the cardiac fibers of the vagus. Novocaine in 0.05 per cent solution has the remarkable action of paralyzing sensory nerve fibers in a degree equal to that of cocaine but in double this strength it has no effect on vagal cardiac fibers.

Tutocaine is only one-third as effective as novocaine on sensory nerve fibers and it has a strong affinity (equal to that of cocaine) for the cardiac fibers of the vagus.

Tutocaine has one-third the anesthetic power of cocaine and seven times that of novocaine on the rabbit's cornea, but the anesthesia is slow in onset. On the human cornea a few drops of a 2 per cent solution of tutocaine give complete anesthesia in about four minutes, which lasts about five minutes to firm pressure with the eye spud; slight smarting and some lacrimation occur, but the irritant effect passes off in one minute. The pupil dilates fifteen minutes after the application and remains slightly dilated for about two hours.

One factor common to most local anesthetics is that they stimulate the central nervous system. When injected subcutaneously in the amounts in which they are likely to be used as local anesthetics their convulsant action can be placed in the following order: cocaine, butyn, tutocaine. Novocaine is much less effective in this relationship and for practical purposes need not be thus considered. This property of giving rise to power-

ful stimulation and excitement of the cerebral cortex is characteristic of one of the two main groups of addiction drugs represented by cocaine, a drug which excites the emotional and relatively lower centers in the cortex.

Copeland's experimental work has been confirmed in the clinic. Lotheissen in 1924 found that the hyperemia produced by the injection of tutocaine cannot be compensated by a greater addition of suprarenin on account of the danger to the tissues. In 1924 Teichert found that tutocaine without sufficient addition of suprarenin loses much of its efficiency.

The data do not permit a very satisfactory conclusion in regard to tutocaine, and its use should be regarded as still in the experimental stage. It is a tissue irritant. Its toxicity for experimental animals is two to four times that of novocaine and nearly approximates that of cocaine and butyn. When compared with novocaine in regard to its clinical effectiveness for infiltration and conduction anesthesia, it offers no advantages; its value is that of a surface anesthetic.

CHAPTER VII

ACTIVE PRINCIPLE OF THE SUPRARENAL GLAND

Oliver and Schaefer, in 1894, were the first to show that extracts prepared from the suprarenals, when injected intravenously into animals cause a marked transitory rise in blood pressure. They further showed that this pressor activity is confined to the medulla and they made attempts to determine the nature of the compound.

The striking effects on blood pressure and the successful clinical use of suprarenal extracts as a local vasoconstrictor soon excited determined efforts to isolate and synthesize the active principle. The activity of the commercial preparations of the dried glands available on the market varied greatly. An extract had to be made on the day it was to be used by boiling a given quantity in water. Its use was not without danger since it was not stable and contained much organic matter.

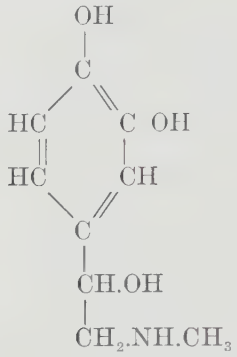
The credit for the isolation of the active principle belongs to Abel, Fuerth, Takamine, and Aldrich. The impure preparation isolated by Abel in 1897 was called epinephrin; the same product isolated by Fuerth in 1898 was called suprarenin. The chemical work inaugurated by Abel paved the way to the isolation of the chemically pure crystalline form which was accomplished almost simultaneously by Takamine and Aldrich in 1901. The chemical structure was definitely established in 1903. The synthesis was first accomplished by Stoltz in 1904 and later, but independently, by Dakin in 1905.

The Council on Pharmacy and Chemistry of the American Medical Association adopted the name epinephrin as the generic word to indicate the active principle of the suprarenal medulla.

Epinephrin was first placed on the market in relatively pure form under the name of adrenalin. The synthetic product is sold under the name of l-suprarenin synthetic. The synthetic preparation originally placed on the market was optically inactive and had only about half the physiologic activity of the natural base. The product now available is levorotatory and is

in all respects identical with the natural product. It is the physiologically active principle of the suprarenal gland, synthetically prepared. It is free from all organic admixtures and keeps practically indefinitely when protected from light, heat, and moisture.

Pure epinephrin is a white microcrystalline odorless powder known chemically as 1, 2, -dihydroxyphenyl-4-ethanol-methylamine with the following formula:



The base is insoluble in the usual organic solvents,—alcohol, ether, chloroform, and water. It is used in the form of a soluble salt, such as the hydrochloride or bitartrate. Epinephrin melts with decomposition at 211° to 212° C. (uncorrected). It thus permits of sterilization by boiling and may be kept at the boiling point of water for several minutes without appreciable impairment of its activity. Only the amount of epinephrin to be used immediately should be sterilized, as it decomposes upon contact with air.

Epinephrin contains an asymmetric carbon atom (with asterisk in formula); consequently there must be two active chemical forms which differ from one another in the effect they produce on the plane of a polarized light, i. e., a dextrorotatory and a levorotatory form. By direct synthesis the dextrorotatory and levorotatory forms are never obtained but always the optically inactive or racemic modification, which is a mixture of equal parts of the two active forms.

The natural epinephrin is levorotatory. Flächer, in 1908, succeeded in separating the optically inactive synthetic epinephrin into the two components, one being optically dextrorotatory and

the other levorotatory. He showed that the physicochemical properties of the levorotatory form and natural epinephrin are identical, both melting at 211° to 212° C. (uncorrected) and both showing the same degree of optical rotation. In 1908, Cushny and also Abderhalden and Müller demonstrated by means of accurately controlled animal experiments that the vasoconstrictor activity of each was the same. The Council on Pharmacy and Chemistry of the American Medical Association have accepted the synthetic levorotatory product under the name of 1-suprarenin synthetic bitartrate. They include it in *New and Non-Official Remedies* and state that it is in all respects identical with the natural product obtained from the suprarenal glands.

The synthetic product is in many ways to be preferred to the natural product. The synthesis involves the use of chemicals of unvarying composition and is controlled at each step so as to yield a pure and uniform product. Natural epinephrin, on the other hand, extracted from enormous quantities of suprarenal glands of varied strength and origin, is likely to contain impurities that are inherent in the process of manufacture.

Scientific progress has been made along the lines of synthesis. No sooner has a natural product of therapeutic value been discovered, than attempts are made to isolate it, to determine its chemical constitution and ultimately to synthesize it. We have such examples in epinephrin and thyroxin (the active principle of the thyroid gland). The isolation and synthesis of insulin would no doubt create a furor in the scientific world and would be a boon to humanity. Once the laboratory synthesis of a natural product is achieved, we are assured of a uniformly pure product which may be prepared at a price low enough to permit of its more general use.

Epinephrin is probably the most powerful physiologic substance known. Locally applied to mucous membranes and open wounds, or injected subcutaneously, epinephrin causes marked vasoconstriction. Tissues infiltrated with solutions of epinephrin become pale and ischemic in a few minutes, and upon incision there is an absence of parenchymatous bleeding, and arterial and venous hemorrhage are markedly diminished. Epinephrin is used with novocaine to intensify and prolong the

anesthesia and to produce a temporary ischemia of the anesthetized tissues.

The concentration of the epinephrin in the anesthetic solution is of importance because it determines the intensity and duration of the anesthesia and ischemia. This ischemia should never be so pronounced as to interrupt the circulation of the blood. It seems generally agreed that the amount of epinephrin used should be from 1:40,000 to 1:100,000. In patients with high blood pressure, heart disease, or goiter; in children, and in the aged, the concentration of the epinephrin should not exceed 1:100,000. One tablet "T" dissolved in 2 c.c. (32 minims) physiologic salt or Ringer's solution prepares a 1 per cent novocaine solution containing suprarenin 1:100,000. The anesthetizing power of this solution is sufficient and the patient reacts much better, is more quiet, and less nervous.

Epinephrin is also widely used as a local application in the mouth and upper air passages for the control of hemorrhage and to lessen the hyperemia or inflammation. To meet these indications, it may be applied directly in the form of aqueous or oily solutions in sprays, by painting, or by instillation. In the nares, sprays, instillations, and ointments which liquefy at the body temperature, or plugs of absorbent material moistened with aqueous solutions are most frequently employed. In coryza and hay fever, such local applications give marked temporary relief. Hemorrhage from the gums is often promptly and permanently checked, and in acute pharyngitis, spraying often gives marked relief of the disagreeable subjective symptoms by lessening the hyperemia. In acute laryngitis and tracheitis the use of aqueous or oily sprays is often of benefit and even the cough of acute bronchitis may occasionally be palliated temporarily by inhalation of finely nebulized oily solutions. Hypodermic injections of epinephrin (1:1000 solution, 0.5 to 1 c.c.) are successfully employed in the treatment of asthma.

In oral surgery, an excellent method of controlling postoperative hemorrhage caused at times by persistent capillary oozing is to use a strip of gauze saturated with suprarenin solution 1:1000. Insert this into the wound between sutures. Pack and fill the wound over the suprarenin with borated or 5 per cent

iodoform gauze strips for forty-eight hours. The gauze should not extend beyond the lips of the wound.

Small doses of epinephrin accelerate and strengthen the heart, but large amounts may cause excessive acceleration, and impair its efficiency. Physicians use epinephrin in heart failure and in surgical shock to restore the circulation and also to combat the symptoms of collapse in infectious diseases.

Uncomfortable and even alarming systemic reactions may occur at times following the subcutaneous administration of slightly excessive doses of epinephrin. The patient experiences a feeling of general distress and anxiety, becomes pale and suffers from a sensation of precordial discomfort and pain, and shivers more or less violently. He may be conscious of an increase in the rate and in the force of the heart action, which may also become decidedly irregular, and rarely he may suffer a more or less typical anginal attack. Occasionally the rise in blood pressure may be pronounced. Vertigo, nausea and vomiting, paresthesias, and heart-burn are other symptoms which occasionally occur. As a rule, these exaggerated and more or less alarming symptoms last only a very few minutes and have no serious results. However, such pronounced effects on the blood pressure and heart action may well prove harmful in cases of hypertension, arteriosclerosis, apoplexy, aneurysm, or feeble dilated heart.

Animal experiments have shown that the toxic action of epinephrin when injected intravenously is enormously increased over that introduced subcutaneously. The fatal dose for experimental animals varies from 0.1 to 0.6 mg. per kilogram of body weight when injected intravenously and from 2.5 to 10 mg. per kilogram when injected subcutaneously. The intravenous injection in rabbits is about forty times as toxic as the subcutaneous.

Toxic symptoms following the injection of epinephrin in animals are evidenced by paralysis of the extremities with tonic and clonic convulsions, opisthotonos, mydriasis, frequent respiration, edema of the lungs, anemia of the viscera, and glycosuria.

With the observance of the special directions regarding the dosage and use of novocaine-suprarenin solution, no serious consequences need be feared. The limits of usefulness of local anesthesia have been materially increased since the introduction of suprarenin. Its results are more certain, the technic in many instances has been simplified, and danger from certain operations has been greatly reduced.

CHAPTER VIII

TOXICITY, SYMPTOMS, AND TREATMENT OF INTOXICATION BY THE LOCAL ANESTHETICS

Accurately controlled animal experiments, showing the relative toxicity of the various drugs used as local anesthetics, have a direct clinical application in supplying unbiased data by which the relative safety of the drugs may be estimated.

Hatcher and Eggleston, in 1919, determined the maximal toxicity of all the drugs used as local anesthetics by rapid intravenous injection of water solutions of the drugs into cats. The concentrations of the solutions varied from 1 to 20 per cent, so that the dose could be injected from a syringe in from five to fifteen seconds.

In 1924 Hooper and Becker determined the maximal toxicity of the local anesthetics by intravenous injection of water solutions in the albino rat. The method used was a modification of the technic employed by the Hygienic Laboratory, United States Public Health Service and that used by the manufacturers to determine the toxicity of the salvarsans before they are released for distribution.

The chart is based upon results obtained with over 300 albino rats. A 2 per cent solution of the drug in distilled water was injected into the saphenous vein at the rate of twelve to fifteen seconds for every 0.1 c.c. At least five animals were injected at each dose. The minimal dose at which any of a series of animals dies is considered the maximal tolerated dose. The dose at which the majority of a series dies is considered the minimal lethal dose.

The abscissae represent the number of milligrams of the drugs injected per kilo body weight. The shaded portions of the ordinates show the maximal tolerated doses, the unshaded portions the minimal lethal doses. The chart shows that butyn is the most toxic of the alkamine esters of the aromatic acids used as local anesthetics. The maximal tolerated dose is 7.5 milligrams and the minimal lethal dose 10 milligrams. The maximal

tolerated dose of cocaine as well as the minimal lethal dose is 12.5 milligrams. The maximal tolerated dose of tutocaine is 22.5 milligrams and the minimal lethal dose is 25 milligrams. The maximal tolerated dose of novocaine is 45 milligrams and the minimal lethal dose is 55 milligrams.

TABLE IV

COMPARATIVE VARIATION IN THE TOXICITY RESULTS OBTAINED IN THE ALBINO RAT AND CAT AFTER INTRAVENOUS INJECTION OF THE ALKAMINE ESTERS OF THE AROMATIC ACIDS USED AS LOCAL ANESTHETICS

	ALBINO RATS		CATS	
	MAXIMAL TOLERATED AND MINIMAL LETHAL DOSES	STRENGTH OF SOLUTION	FATAL DOSE	STRENGTH OF SOLUTION
	Mg. per kg.	Per cent	Mg. per kg.	Per cent
Butyn	7.5–10	2	15*	1
Alypin	10–15	2	10†	5–10
Cocaine	12.5	2	15†	5–10
Isocaine	15	2	—	—
Tropacocaine	15–20	2	18–22†	10
Apothesine	20	2	20†	5–10
Beta-eucaine	15–25	2	10–12.5†	5
Tutocaine	22.5–25	2	—	—
Stovaine	25–30	2	25–30†	10
Novocaine	45–55	2	40–45†	5–20

*Fatal dose obtained by Professor Robert A. Hatcher. See Bonar, M. L., and Sollman, Torald: Jour. Pharmacol. and Exper. Therap., 1922, xviii, 475.

†Fatal doses obtained by Professors Cary Eggleston and Robert A. Hatcher: Jour. Pharmacol. and Exper. Therap., 1919, xiii, 444.

In the first column are given the local anesthetics employed; in the second column the maximal tolerated and minimal lethal doses for the albino rat in milligrams per kilo body weight; in the third column the strength of the solution injected into the saphenous vein of the rat; in the fourth column the fatal dose for the cat obtained by Professors Hatcher and Eggleston by their rapid intravenous injection method, and in the fifth column the strength of the solution injected.

It will be noted that the results obtained by the two methods are quite comparable and that there is very little variation in the maximal toxicity for the two species when the drugs are injected intravenously.

We have accepted the experiments of Hatcher and Eggleston and of Hooper and Becker because the results obtained are based upon accurately controlled intravenous experiments. The toxic action of the local anesthetics is exerted only after the entrance of the drugs into the blood stream. The rate of absorp-

tion of the local anesthetics when injected subcutaneously or intramuscularly varies greatly in different species of animals, and when injected into the same species there is also a marked variation in the rate of absorption depending upon the site of injection.

In 1919, the American Medical Association took an active interest in the study of the advantages and disadvantages of the various local anesthetics. Acting on the request of the Therapeutic Research Committee of the Council on Pharmacy and Chemistry, the investigating Committees on Local Anesthetics have made three reports, in the years 1920, 1921, and 1924 respectively. In their final report they compiled 43 deaths following the use of the various local anesthetics. Twenty-six of the deaths were caused by cocaine or the combined use of cocaine and procaine. Eight of the deaths were avoidable deaths caused by the substitution of cocaine for the required procaine (novocaine). These mistakes were probably made on account of the similarity of the names cocaine and procaine. Four of the deaths were caused by butyn, and four by apothesine.

Alypin and stovaine each caused one of the deaths reported to the Committee, but this fact does not indicate that they are of low toxicity and the relative infrequency with which they are used should be borne in mind. Two members of the Committee reported that apothesine caused most frequent complaint among those who reported to them, especially because of the sloughing that followed its use.

The four deaths reported after the use of butyn indicate the necessity of caution in its use. Two of these deaths followed within a few minutes after the application of a 5 per cent solution of butyn to the nose.

Novocaine is used far more frequently than any other local anesthetic, but it caused only one of the fatalities.

The dangers of substitution of cocaine for procaine (novocaine), resulting from verbal orders pronounced indistinctly, cannot be emphasized too strongly. Especial precautions should be taken to avoid such mistakes, which have not only caused several deaths, but also numerous accidents of less serious nature.

As a matter of precaution it is advisable to have but one local anesthetic at hand; to use the sealed ampules; to adhere closely to the dosage recommended as being safe, and to use such local anesthetics as are reasonably free from danger. The Committee has gone on record as stating that novocaine is the safest of all local anesthetics now in general use.

Many operators use stock solutions which are kept on hand for some time and which do not remain sterile; some of those used by dentists contain epinephrin, which decomposes on standing. Many use hypodermic needles without sterilizing them; often the area of injection is not disinfected; many dentists use local anesthetics without sufficient knowledge of their actions and the indications for their use.

Local anesthetics are administered to millions of individuals every year; we also know that sudden death occurs among patients who have received no treatment, and it seems certain that the local anesthetics had little to do with the fatal outcome in several unpublished cases reported to the Committee. Not only is it necessary to know that a local anesthetic was administered before death, but we must know that the symptoms were those commonly induced by it before we are justified in attributing death solely to the anesthetic used.

In all of those instances in which death was surely due to the local anesthetic, the toxic symptoms were practically the same. In these cases death occurred very quickly, usually before any operation could be performed. The effects in man are strikingly similar to those induced experimentally in animals. Convulsions and failure of respiration were usually observed within a few minutes after the administration of the local anesthetic.

The reports of fatalities afford no evidence that epileptics are especially sensitive, and it may be added that while status lymphaticus is mentioned frequently in the necropsy records, the Committee is of the opinion that status lymphaticus is not a frequent cause of death with the local anesthetics.

Local anesthesia is undoubtedly much safer than general anesthesia. The local anesthetics act electively on the sensory nerve endings or nerve trunks in a circumscribed area and do not depress the central nervous system. The anesthetic fluid acting

as a dye, impregnates the nerve tissues at the site of injection. The injected anesthetic, therefore, only partially reaches the blood stream where, according to its specific toxicity, it may produce general symptoms of intoxication.

Dunning states that a reversion against local anesthesia is generally due, first to postoperative pain, and secondarily to the fact that the local anesthesia had made the patient feel peculiar for a period before the operation and also afterward.

Postoperative pain can be lessened by using greater caution in the manner in which the anesthetic is injected and by reducing the strength of the solution. Many operators feel that they can "shoot" the anesthetic fluid in, at almost any place, and in almost any strength and dosage. Often the oral surgeon does not fully realize that the patient is very toxic, at least, locally. Within the operative field there may be millions of virulent bacteria whose conduct will not be improved by the injection of a local anesthetic, however mild and innocent it may be.

Without a radiograph one cannot tell whether there is an infected area in the bone. At times there may be an active infection present that will not appear on the film. If an injection is made into the periosteum in which are locked millions of bacteria of a virulent nature there will result more postoperative irritation, hence more pain, than if a general anesthetic were used.

As stated before, postoperative complications, such as severe hyperemia, inflammation, painful infiltrates, sloughs, or necrosis, have frequently been attributed to novocaine when they were either the result of infection, the addition of an excessive amount of suprarenin, or the use of hypertonic salt solution as the vehicle.

Seibert, in 1913, showed that the concentration of the suprarenin should never be sufficient to cause a complete cessation of bleeding. The medium-sized arteries should be permitted to bleed so that they can be ligated and the possibility of secondary hemorrhage avoided. If the ischemic action of suprarenin is too intense, tissue gangrene may result, especially in tissues whose nutrition has already been disturbed.

In 1919, Braun showed that salt solutions alone, containing more than 0.9 per cent of sodium chloride, cause symptoms of dehydration, such as irritation, paralysis, and damage to the tissues. Skin wheals produced with hypertonic salt solutions are quite characteristic. With the subsidence of the burning pain and the beginning of anesthesia the wheal quickly becomes depressed in the center, the margins remaining elevated in the form of a circular ridge. The anemic center and surrounding margin are separated by a narrow red ring. In about fifteen minutes the swelling flattens out uniformly, extending from the center toward the periphery, and sensation gradually returns. The intensity of all these phenomena increases with the concentration of the salt solution. They are noticeable at 2.5 per cent, and more than 10 per cent salt solution can hardly be borne.

Hooper, in 1924, described several cases of necrosis of the skin and subcutaneous tissue in patients operated under local anesthesia. In two of the cases a wide sloughing occurred,—in one, of the skin and of the subcutaneous tissue, and in the other, of the deeper structures as well. Upon investigation it was found that the tissue damage was caused by the use of hypertonic salt solution in the preparation of a novocaine solution, instead of physiologic salt solution (0.6 per cent). Two of the solutions were analyzed and were found to contain *6.3 per cent* and *30.6 per cent* sodium chloride respectively. He asserts that the accidental use of concentrated salt solution in the preparation of a novocaine solution will usually lead to extensive tissue necrosis, sloughs, and gangrene, which may require months to heal. If such a solution is injected into a nerve trunk a permanent paralysis may result.

Some patients feel that they have been poisoned by the anesthetic, even two or three weeks after the operation. It is difficult to explain to these patients that the solution has long since left the body and that the pain is due to their own infection; namely, an infection of the bone that has caused an acute inflammation, due to the fact that this part of their anatomy has received operative trauma, and that bacteria plus trauma equals pain.

A dislike of local anesthesia on the ground that it makes a patient feel peculiar, shaky, nauseated, and uncomfortable, with

a thumping heart, precordial pain, shortness of breath or faint, verging toward collapse, is generally due to the operator having failed to diagnose his patient's condition, locally and generally. He is often so anxious to begin the operation, that he fails to appreciate that the patient is perhaps over fifty and has a sallow complexion. He neglects the pulse and in his eagerness to begin work and in his desire not to hurt the patient he injects at once and often too fast, a 2 per cent solution with the patient in an upright position.

The trouble can generally be avoided by examining the general condition of the patient before operation. Patients not in good condition should be placed in a reclining position and 0.5 per cent solution injected slowly. No patient of fifty years, or over, should be given more than 0.5 per cent solution, because one may expect some heart or vascular disturbance. The apprehensive patient should be made to feel that he is absolutely safe and that nothing can happen.

On the slightest suggestion of trouble the operator should instruct the nurse to apply aromatic spirits of ammonia on a piece of gauze to the nose. He should tip the chair backwards so that the patient's head is lower than his feet. By this time the window should have been opened. The patient is watched closely for further signs of distress. The pulse and respiration are carefully noted, and the patient is not disturbed until his condition has become quite normal again. When the operator feels that the patient has recovered, the injection of the solution may be resumed with the patient lying extended, care being exercised to note immediately any further disturbance. If the patient is going to have trouble, the symptoms appear almost immediately after the initial injection. He revives quickly if properly cared for promptly.

Dunning states that about 95 per cent of all cases can be handled under local anesthesia better than with general anesthesia. He further states that it is a great mistake to use local anesthesia in children unless one has absolute control of the patient. One should not inject infected patients, reeking with suppurative gingivitis, or when the mouths are filthy. They should be cleaned up, and later a general anesthetic administered. It is

also a mistake to inject ankylosed patients. When a general anesthetic is necessary, the patient should be placed in a hospital where he is surrounded by all the necessary safeguards.

The application of local anesthesia on the jaws, teeth, and associated parts is a most scientific procedure. The production of local anesthesia by conduction or infiltration anesthesia is one of the triumphs within the domain of dentistry and oral surgery. The use of conduction anesthesia for the performance of dental operations is almost unlimited. The surgeon should know his solution and its percentage. The injection should be made slowly at the rate of one cubic centimeter of the solution in from one-half to one minute. This takes time but the anesthetic results obtained are far superior to those obtained through rapid injection, and the postoperative results are more gratifying.

Care must be taken not to inject the solution into the blood stream. During the injection the patient should be observed carefully. The operator must be quick to notice any signs of paleness, tremor, or perspiration, and must also remember that some patients faint on trivial occasions. He must watch the needle, and not let it bend. He must see that the solution is not escaping at the point of entrance of the needle, he must not allow his hand to obstruct the view of the point of injection.

A sterile solution, a sterile syringe, and a sterile needle will obviate any possibility of needless suffering to the patient and will relieve the operator of considerable anxiety.

The syringe must be so constructed that it will readily permit of sterilization by boiling each time it is to be used. It should be equipped with an extension hub of sufficient length to permit the operator to have an unobstructed view of the field within the mouth during the entire procedure of making the injection.

The needles should be selected of sufficient length so that there will always be at least one centimeter exposed between the hub and the punctured tissues; this will permit the needle to bend without breaking. In cases of inherent weakness in the needle and if accidental breakage should occur, the extra length will facilitate its removal from the tissues. The needles should be sterilizable by boiling. Sharp pointed needles of small caliber should be employed in order to produce a minimum amount of laceration.

The mucous membrane at the site of the injection should be massaged with a solution composed of equal parts of tincture of aconite and tincture of iodine.

Isolated cases of professional dermatitis have been reported among dentists who have an inherent or acquired susceptibility for the various local anesthetics. The dermatitis is not a progressive disease, the eruption involves only the skin that comes in direct contact with the local anesthetic and it is not accompanied by any systemic disturbance. It is readily cured by discontinuing contact with the drug either by total abstinence or the wearing of rubber gloves, thoroughly cleansed with water before and after each use of them.

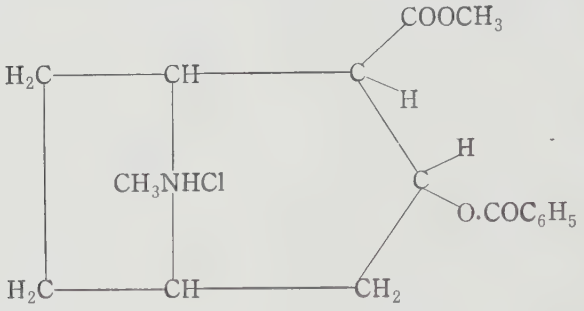
There is no evidence that persons susceptible to procaine dermatitis, who subsequently receive injections of novocaine for the extraction of teeth, or for other operative procedures, develop a local reaction at the site of the injection or show any general symptoms. Further, there is no evidence that persons who have received injections of novocaine for the extraction of teeth or for other operative procedures develop a hypersusceptibility to the drug. Chemists engaged in its production have had such injections. They come into daily contact with large quantities of the drug in every form of concentration and purity, without ill effects of any kind.

It should be remembered that novocaine has no cumulative action because it is rapidly eliminated by destruction in the liver. If untoward symptoms develop they will occur almost immediately after the injection of the solution. A local anesthetic eliminates physical pain, but it does not eliminate psychic impressions. Therefore, the operator should be on his guard at all times, using diplomacy and tact, always obtaining the confidence of the patient before making the injection or before beginning to operate. Every precaution should be taken to avoid psychic shock and the operator should handle the tissues carefully, bearing in mind that delicate performance of the technic is essential and that thoroughness should never be sacrificed for speed. These are steps in oral surgery that should never be forgotten.

CHAPTER IX

RÉSUMÉ OF IMPORTANT LOCAL ANESTHETICS

Cocaine—Hydrochloride of methyl-benzoyl-ecgonine.—

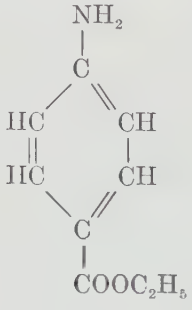


Isolated from coca leaves by Niemann in 1858, and introduced as a local anesthetic by Koller in 1884.

The alkaloid cocaine, for over twenty years the only practical local anesthetic, has gradually fallen into disuse, and is now regarded as a very dangerous drug. The majority of surgeons who still employ cocaine restrict its use to topical applications, and state that it should never be injected beneath the skin. It is a habit-forming drug and its sale and distribution are governed by the Harrison Anti-Narcotic Act.

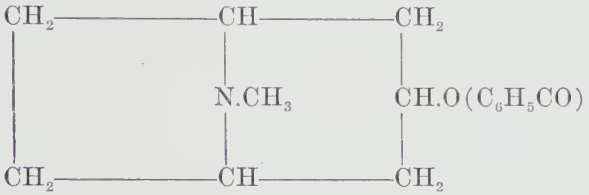
Psicaine, an optically active isomer of cocaine, was prepared by Willstätter in 1924. Its anesthetic efficiency is less than cocaine and its toxicity is approximately the same.

Parathesin (Anesthesin)—Ethyl-para-amino-benzoate.—



Prepared by Ritsert in 1890. It is practically nontoxic and possesses strong anesthetizing properties when in direct contact with exposed nerve ends. Owing to its insolubility in water and tissue fluids, parathesin cannot be used by hypodermic injection. It is valuable as a pain-relieving application, either in powder form or as a salve, for the relief of pain following extraction of teeth, for pain due to pulpitis and for wounds, burns, ulcers of the stomach, etc. The most delicate tissues tolerate parathesin without the slightest symptom of irritation.

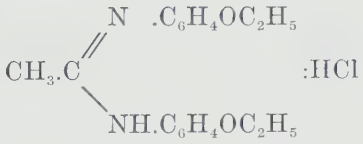
Tropacocaine—Hydrochloride of benzoyl-pseudotropein.—



Isolated from the leaves of the Java coca plant by Giesel in 1891. Prepared synthetically by Liebermann in 1892.

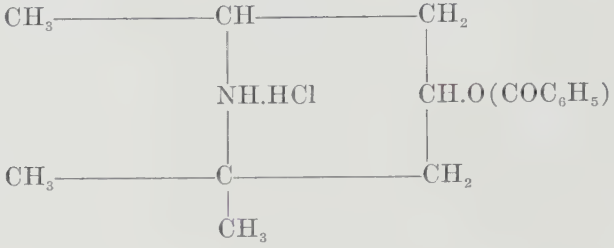
The alkaloid is slightly less toxic than cocaine. It is a tissue irritant. The local application of tropacocaine produces an anesthesia of too fleeting a nature. It is unsuitable for use in infiltration and conduction anesthesia. It is a habit-forming drug and its sale and distribution are governed by the Harrison Anti-Narcotic Act.

Holocaine—Hydrochloride of Phenetidyl-aceto-phenetidin.—



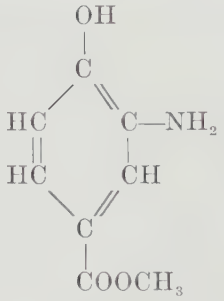
Prepared by Täuber in 1897. It is an eye anesthetic, twice as efficient as cocaine and the anesthesia occurs more quickly. It does not alter the size of the pupil, dry the cornea, nor affect the circulation of the interior of the eye. Holocaine solutions are strongly antiseptic. Its toxicity approximates that of cocaine and butyn.

Beta-Eucaine—Hydrochloride of 2, 6, 6,-trimethyl-4-benzoyl-piperidin.—



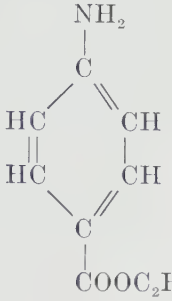
Described by Vinci in 1897. It is three times more toxic than novocaine, one-third less effective, and produces a mild hyperemia when injected.

Orthoform—Methyl-meta-amino-para-oxybenzoate.—



Prepared by Einhorn and Heinz in 1897. In physiologic activity orthoform is on a parallel with parathesin. It is somewhat antiseptic and practically nontoxic. It is soluble with difficulty in water, readily soluble in alcohol and the fatty oils, and is used either in powder form or as a salve. Like parathesin, its use is limited to direct application to tooth sockets, wounds, ulcers, burns, etc. Orthoform like cocaine paralyzes all the peripheral sensory nerve endings and nerve trunks with which it is brought into direct contact.

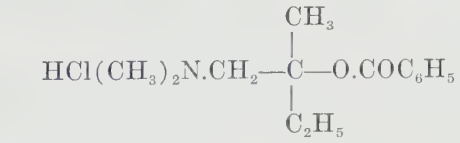
Novocaine—Hydrochloride of para-amino-benzoyl-diethyl-amino-ethanol.—



Prepared by Einhorn in 1904, and introduced by Braun in 1905. Novocaine is the safest and most effective of the synthetic cocaine substitutes so far introduced into surgery. When injected subcutaneously it exerts the same action upon the peripheral sensory nerves as cocaine and when combined with suprarenin it produces an equally pronounced and lasting anesthesia. It is not a habit-forming drug.

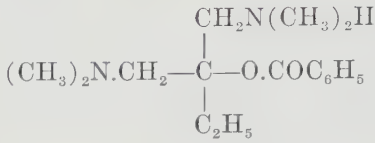
Novocaine most nearly fulfils the requirements of the ideal local anesthetic and has practically superseded all other local anesthetics for infiltrations and conduction anesthesia. It is highly anesthetic, relatively nontoxic, easily sterilized in aqueous solution, nonirritating to tissues and compatible with suprarenin. One of the most important advantages of novocaine is the possibility of safely injecting large quantities of its solutions into the body. This fact has greatly broadened the scope of local anesthesia, and has been largely responsible for the extensive development of regional anesthesia.

Stovaine—Hydrochloride of benzoyl-ethyl-diamino-propanol.—



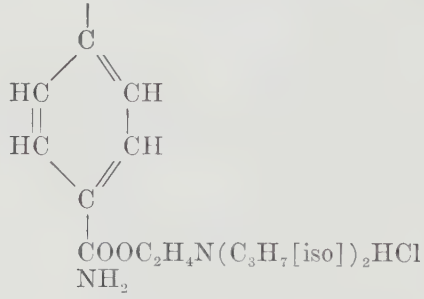
Prepared by Fourneau in 1904. Its water solutions are strongly acid to litmus and when injected beneath the skin produce definite tissue injury. Several cases of gangrene have been reported following the use of a 2 per cent solution. Stovaine is therefore unsuitable for local anesthesia.

Alypin—Monohydrochloride of benzoyl 1, 2,-dimethyl-amino-3-ethyl-isopropanol.—



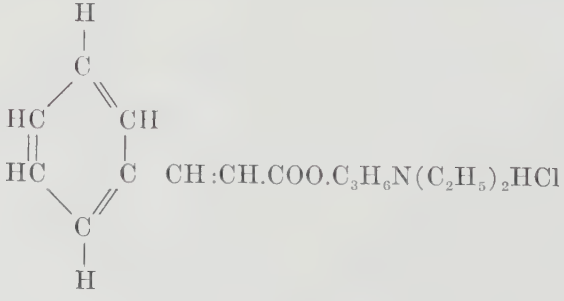
Prepared by Hoffmann in 1905. Its toxicity approximates that of cocaine. The injection of alypin is painful and is frequently accompanied by very noticeable tissue injury. The use of solutions of alypin for injection is contraindicated, since we have other agents which do not produce injurious effects.

Isocaine—Hydrochloride of para-amino-benzoyl-di-iso-propyl-amino-ethanol.—



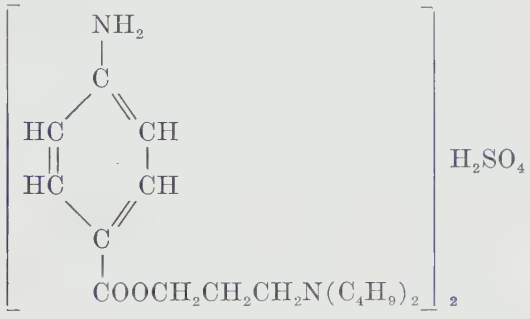
Prepared by Einhorn in 1909. The toxicity of isocaine approximates that of cocaine. It is practically as efficient as cocaine for anesthetizing the rabbit's cornea and has no irritating action. On account of its toxicity it should not be used as an injection anesthetic.

Apothesine—Hydrochloride of gamma-diethyl-amino-propyl-cinnamate.—



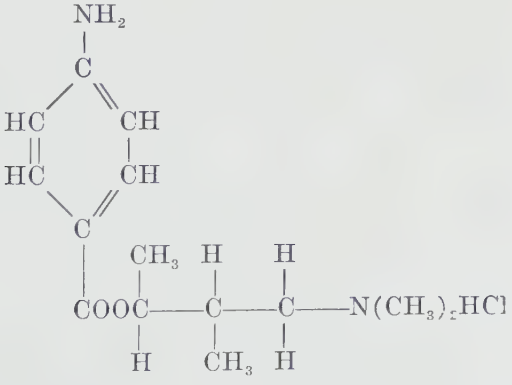
Prepared by Wildman and Thorp in 1916. Apothesine is more than twice as toxic as novocaine. Its anesthetic efficiency averages considerably below novocaine (Sollman in 1918). Apothesine was not accepted by the Council on Pharmacy and Chemistry until 1924, on account of the fact that the drug was advertised to be as potent as cocaine and to have a low toxicity. The Mayer Committee states that apothesin caused the most frequent complaint among those who reported to them, especially because of sloughing that followed its use.

Butyn—Sulphate of para-amino-benzoyl-gamma-dinormal-butyl-aminopropanol.—



Homologue of novocaine prepared by Kamm, Adams, and Volweiler in 1920. It is somewhat more toxic than cocaine and when compared with cocaine in regard to its clinical effectiveness it has few, if any advantages. Butyn should not be injected and for topical applications, concentrations not greater than 2 per cent should be used.

Tutocaine—Hydrochloride of para-amino-benzoyl-dimethyl-amino-beta-methyl-isobutanol.—



Homologue of novocaine prepared by Schulemann in 1922. Tutocaine is only one-third as effective as novocaine on sensory nerve fibers and has a strong affinity (equal to that of cocaine) for the cardiac fibers of the vagus. Its toxicity for experimental

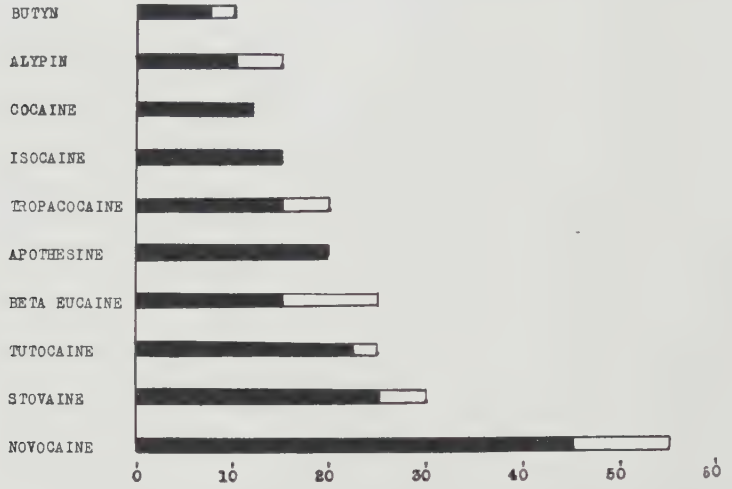


Fig. 4.—Chart showing quantitative comparison of the toxicity of the alkamine esters of aromatic acids used as local anesthetics. Rats injected intravenously. Maximal tolerated (black) and minimal lethal (white) doses in milligrams per kilogram body weight.

animals is two to four times that of novocaine and nearly approximates that of cocaine and butyn. It acts as an irritant to tissues when injected subcutaneously, producing marked hyperemia and thickening.

CHAPTER X

THE INSTRUMENTARIUM FOR LOCAL ANESTHESIA

In the selection of the instrumentarium for local anesthesia, the desirability of sterilization by boiling must be kept in mind as of major importance.

The syringe, the most important item of our armamentarium, should be devoid of washers, particularly those of the leather or felt variety. The hubs should be ground to fit the particular syringe. The glass should be of a consistency to admit of boiling.

With the aid of the Becton-Dickenson Company, I have designed a syringe which will adequately serve the purpose. The glass barrel is made of practically alkali-free, hard glass, which is not affected by change of temperature. The syringe can be placed in boiling water or from boiling water into cold water without danger of breakage. The metal piston is made of rust-resisting steel which can be kept in the barrel while sterilizing. No soldering material is used for fastening the collar and the finger rest to the glass barrel. The metal collar fits loosely over the barrel and has an inside parallel spring which rests against the glass flange. The spring neutralizes the pressure exerted while injecting and prevents breaking of the flange. The top cap has an inside friction spring which presses against the piston rod and prevents the piston from accidentally slipping forward or backward.

The syringe has the Luer lock arrangement; one-half turn to the right securely locks the needle and no amount of pressure will cause it to leak or to fly off, yet it can be quickly released by one-half a turn to the left. No special needles are required, every Yale Luer needle will fit and lock, thus eliminating the need for carrying an extra stock of special hub needles. The syringe is designed to give the utmost comfort and security to the operator.

Another excellent type of syringe is the one designed by Dr. Gaston Labat. The use of faultily constructed syringes has un-

doubtedly led a number of men to discard local anesthesia. After having obtained a satisfactory syringe they find that the hubs do not fit, or that the needles do not fit the hubs, in the majority of cases due to their being too thin, with subsequent leakage at the hub.

The use of all metal syringes should be discouraged, since the presence of foreign particles, air, or the color of the solution, cannot be determined.

Syringes which can be sterilized by boiling do not require their immersion into jars containing alcohol and glycerine, thus avoiding the danger of producing prolonged anesthesia through the injection into the tissues of a portion of the alcohol which has remained in the syringe.

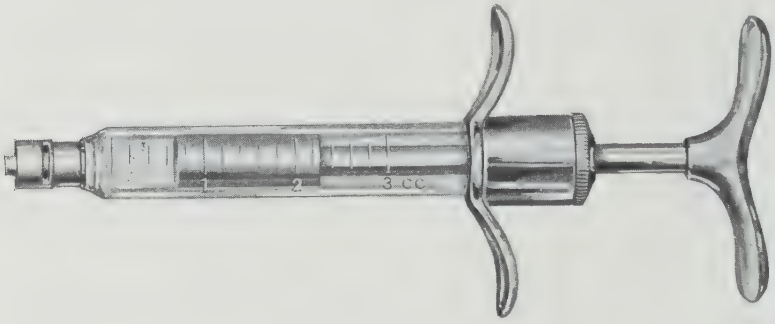


Fig. 5.—Winter hypodermic syringe.

Crucibles, used for dissolving novocaine, should be of alkali-free Jena or Pyrex glass, or of chemical porcelain. Silver, gold, or platinum cups should not be used as these metals act as catalyzers, permitting of the ready oxidation of suprarenin, and rendering it inert. The glass or porcelain cups are marketed in two sizes—3 c.c. and 10 c.c., graduated.

Needles

The needles used for local anesthesia may be constructed of steel, of nickel, or of platinum-irridium. The best type is the needle which is attached to the hub, thus insuring a perfect fit of hub and needle.

For infiltration anesthesia a short needle—26 mm. in length, 0.47 mm. in diameter—will serve the purpose admirably; for

conduction anesthesia, a needle 42 mm. in length, and 0.55 mm. in thickness is best suited.

Steel needles should not be used for too long a time; a good practice is to discard the needle after having used it two or three times.

Irridio-platinum needles are excellent, for in an emergency they may be sterilized by passing them through a flame. However, it must not be expected that they will do the impossible. Repeatedly bending the needle and again straightening it, causes

Fig. 6.—Showing method of boiling Ringer's solution, which is to be used as the solvent for novocaine, by holding a porcelain crucible over an alcohol lamp or Bunsen burner.

it to become weak at the particular point, with subsequent breakage. Heavy steel needles have been recommended in order to avoid breakage. It must be clearly recognized, however, that no material will prevent breakage, but rather it should be kept in mind that when the needle comes in contact with an obstruction, it is to be withdrawn and no effort made to force it through bone, since such an attempt, regardless of the consistency or thickness of the needle, can only result in its breakage.

Wherever possible the instrumentarium for the preparation

and injection of novocaine should be segregated. A small sterilizer, exclusively for this purpose, should be at hand. If we are to use novocaine at all, we should not deviate one iota from the prescribed technic of its preparation.

Wherever possible we should avoid contamination of the instrumentarium with the anti-rust substances placed in the common sterilizers.

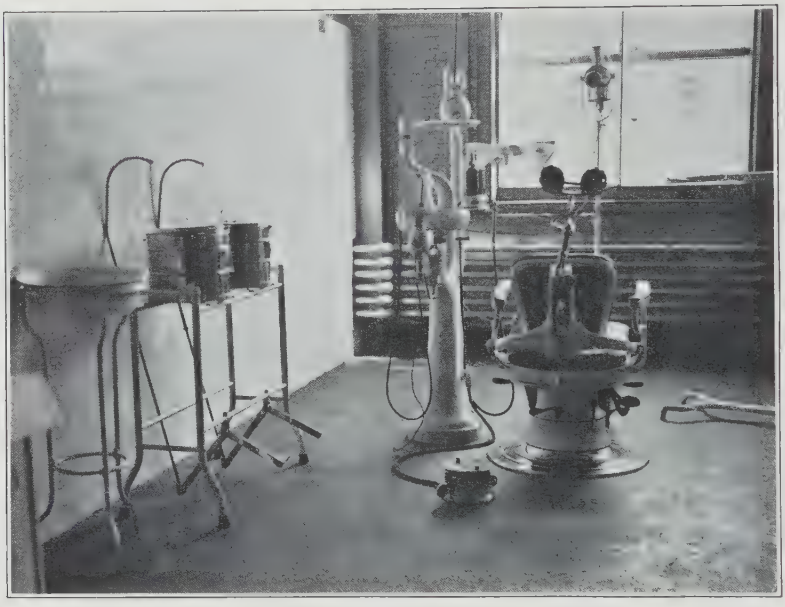


Fig. 7.—Local anesthesia room of the Oral Surgery Clinic, New York University College of Dentistry. All armamentarium of local anesthesia is sterilized in this room. By this method of segregation, no contamination of any instruments of the local anesthesia armamentarium is possible.

The best solvent for novocaine is Ringer's solution. This is best prepared by placing one Ringer tablet in a graduated porcelain crucible, adding slightly more than 10 c.c. of sterile distilled water, and holding the crucible over a Bunsen burner or alcohol lamp until the tablet is dissolved. The extra amount of sterile distilled water, amounting approximately to one-half cubic centimeter, allows for evaporation. The preparation of fresh Ringer's solution for each individual case will eliminate any danger of contamination, which is possible when the solution is prepared in bulk and kept in stock bottles.

Success in local anesthesia is dependent upon several impor-

tant factors. Of prime importance is asepsis, not alone of the needle, syringe, and solution, but also, in so far as possible, of the field of operation and site of introduction of the needle. Premedication is an important adjunct to local anesthesia. Cooperation on the part of the patient is essential. If we are dealing with the type of patient who cannot conceive of the possibility of being conscious and free from pain at the same time, premedication becomes necessary.

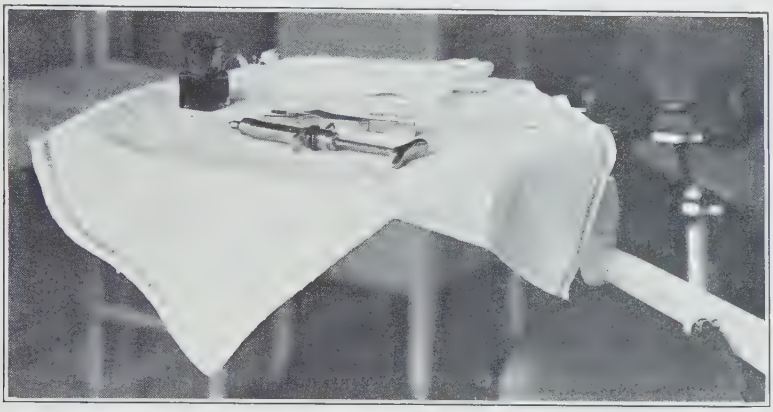


Fig. 8.—Proper tray for local anesthesia. Sterile towel on bracket table, hypodermic syringe, sterile applicators, thumb forceps, tincture of iodine, and gauze swabs. The swabs to be used by the aid of the thumb forceps to dry the mucous membranes, prior to the application of the tincture of iodine. Having thumb forceps at hand, a broken fragment of a needle may readily be grasped when this accident occurs.

Sterilization of the site of injection is readily accomplished by the use of iodine and aconite, equal parts, diluted with alcohol. This compound should be applied thoroughly by aid of a sterile applicator. It is good practice to take the proper position for making the injection, to use a small sponge of sterile gauze to wipe away any mucus or débris which may have collected on the surface, then to apply the iodine and aconite, and while the finger is still in position, to make the injection.

CHAPTER XI

EXTRA-ORAL INJECTIONS

Injections for anesthetization of the nerves supplying the maxillae or mandibles by the extra-oral route should be resorted to in cases where local anesthesia is the choice and where, due to the presence of an infection or trismus, in varying degrees, the intraoral injection is precluded or made difficult.

Technic for Extra-Oral Injection

Maxillary Nerve Block (Extra-Oral or Zygomatic Route).— The sigmoid notch is outlined by placing the tip of the index finger of the left hand, nail turned vertically upward, just below the zygomatic arch and asking the patient to open and close the mouth. The depression felt by the ball of the finger is the sigmoid notch. The bisector of the tip of the finger nail marks the middle point of the zygoma; the site of puncture is just below it.

With a very thin needle, an intradermal wheal is raised at the site of puncture, thus determined, so that the passage of a larger needle may be painless. A needle, 80 millimeters long, provided with a recorder (piece of rubber or cork that slides up and down its shaft), is passed through the wheal in a direction perpendicular to the median plane of the head, and is introduced about half its length, until contact is made with the base of the pterygoid process. The recorder is set at a distance of one centimeter from the surface of the skin. The needle is withdrawn sufficiently so that its direction may be changed and then reintroduced in a direction *slightly* forward and upward until the recorder touches the surface of the skin. The point of the needle has thus passed in front of the pterygoid process into the sphenomaxillary fossa.

The syringe is now connected to the needle and the aspiration test made so as to be sure that the injection is not being made in a blood vessel. The aspiration test is best accomplished by

injecting two or three drops of the anesthetic solution immediately after connecting the syringe to the needle and pulling the plunger backward. If blood is aspirated by this maneuver or comes out of the needle at any stage of the technic, the needle should be withdrawn entirely, washed thoroughly, and the whole

Fig. 9.—Maxillary block by the extra-oral or zygomatic route. The site of puncture is just below the middle point of the zygomatic arch. The mandibular block is accomplished through the same site of puncture.

procedure started over again. If the aspiration test is negative injection of 2 or 3 c.c. of a 2 per cent novocaine solution is made, *without moving the needle.*

Paresthesias (shooting pains) in the upper jaw are occasionally induced, but they must not be sought, except when alcohol injections are made for the relief of tic douloureux (Labat).

Mandibular Nerve Block (Extra-Oral or Zygomatic Route).—The technic is similar to that of the maxillary nerve block, but instead of passing the needle in front of the pterygoid process it is directed backward toward the foramen ovale, which is ordinarily approached before the recorder has reached the surface of the skin. The foramen ovale lies just posterior to the base of

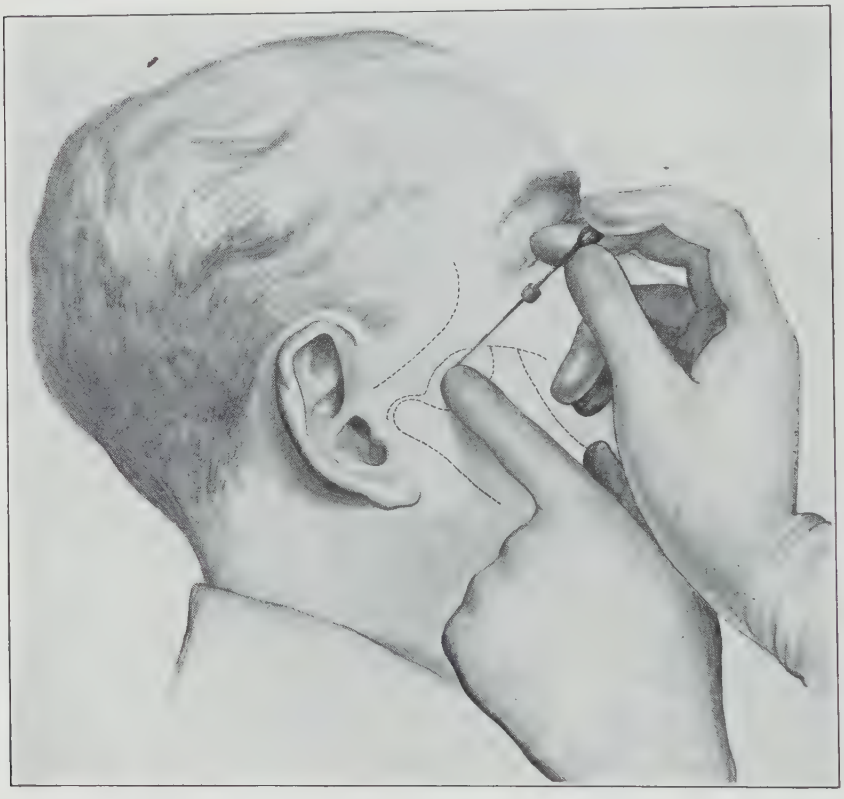


Fig. 10.—Maxillary block by the extra-oral or zygomatic route. The middle point of the zygoma is defined by placing the ball of the index finger of the left hand just below the zygomatic arch in the depression of the sigmoid notch. The bisector of the tip of the finger nail is the desired point and the site of puncture.

the pterygoid process and is at about the same depth as the outer surface of the lateral plate of the pterygoid process. The setting of the recorder at a distance of one centimeter from the surface of the skin in this situation is to prevent the introduction of the needle into the deeper structures where damage can be done to the large blood vessels. Paresthesis in the lower jaw or in the ear and temple are the best indications that the nerve

has been reached. They are of frequent occurrence even when the technic is accomplished with care and precision. The nerve should not be traumatized. Gentleness should be exercised when introducing the needle, and as soon as paresthesias are induced

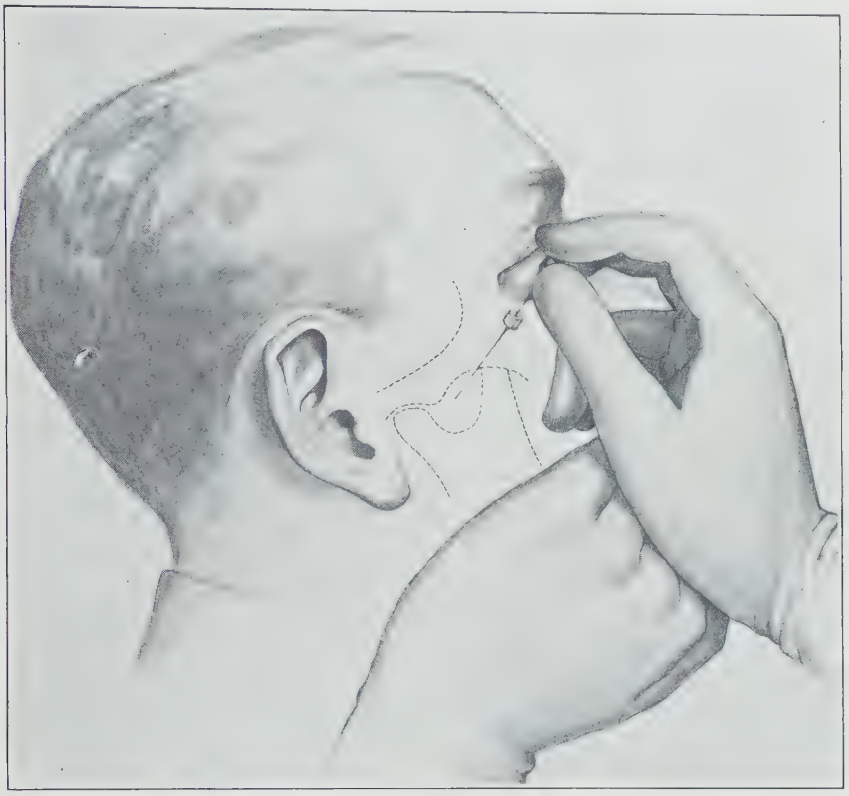


Fig. 11.—Maxillary block by the extra-oral or zygomatic route. The needle is introduced just below the middle point of the zygomatic arch in a direction perpendicular to the sagittal plane of the head until it takes contact with the pterygoid process, after which it is passed in the sphenomaxillary fossa. The head is steadied by the left hand; the right hand is supported by the left.

the needle must be withdrawn very slightly (about one millimeter) and the injection started after obtaining a negative aspiration test (Labat).

CHAPTER XII

TECHNIC OF INJECTIONS

Anesthesia of the pulp and of the dentin, such as would be necessary for pulp extirpation, root canal treatment, obturation or crown and bridge work, is best accomplished by means of infiltration. The needle should be inserted midway between the gingival margin and the apex of the tooth under treatment,

Fig. 13.—Position for the injection of the right mandibular nerve. The patient's mouth should be opened to the fullest extent, with head in almost vertical position. The left index finger is placed directly behind the last molar. In so doing, we feel a sharp ridge. This is the external oblique ridge, approximately 1 cm. above the occlusal surfaces of the molar teeth. The syringe is held with the pen grip, the beveled edge of a 42 mm. needle toward the bone, and it should rest on the occlusal surfaces of the first and second bicuspid teeth on the opposite side. The needle is then inserted into the mucous membrane at a point approximating the middle of the finger nail. When we strike bone, we stop, slightly withdraw the needle, and then by the aid of the index finger push the needle inward slightly, bring the syringe toward the center of the mouth and permit the needle to glide along the inner border of the ramus until we feel the resistance is lost. When this is accomplished, the needle will have passed over the lingula which is the prominence guarding the orifice of the inferior dental canal. The solution is here discharged by the aid of a slight pumping motion. The reason for this slight pumping motion is that it is never necessary to inject the nerve directly, the infiltration of the alveolar tissue surrounding this nerve trunk will carry the novocaine to the nerve. Care must be taken to keep the needle in as close contact with the bone as possible at all times.

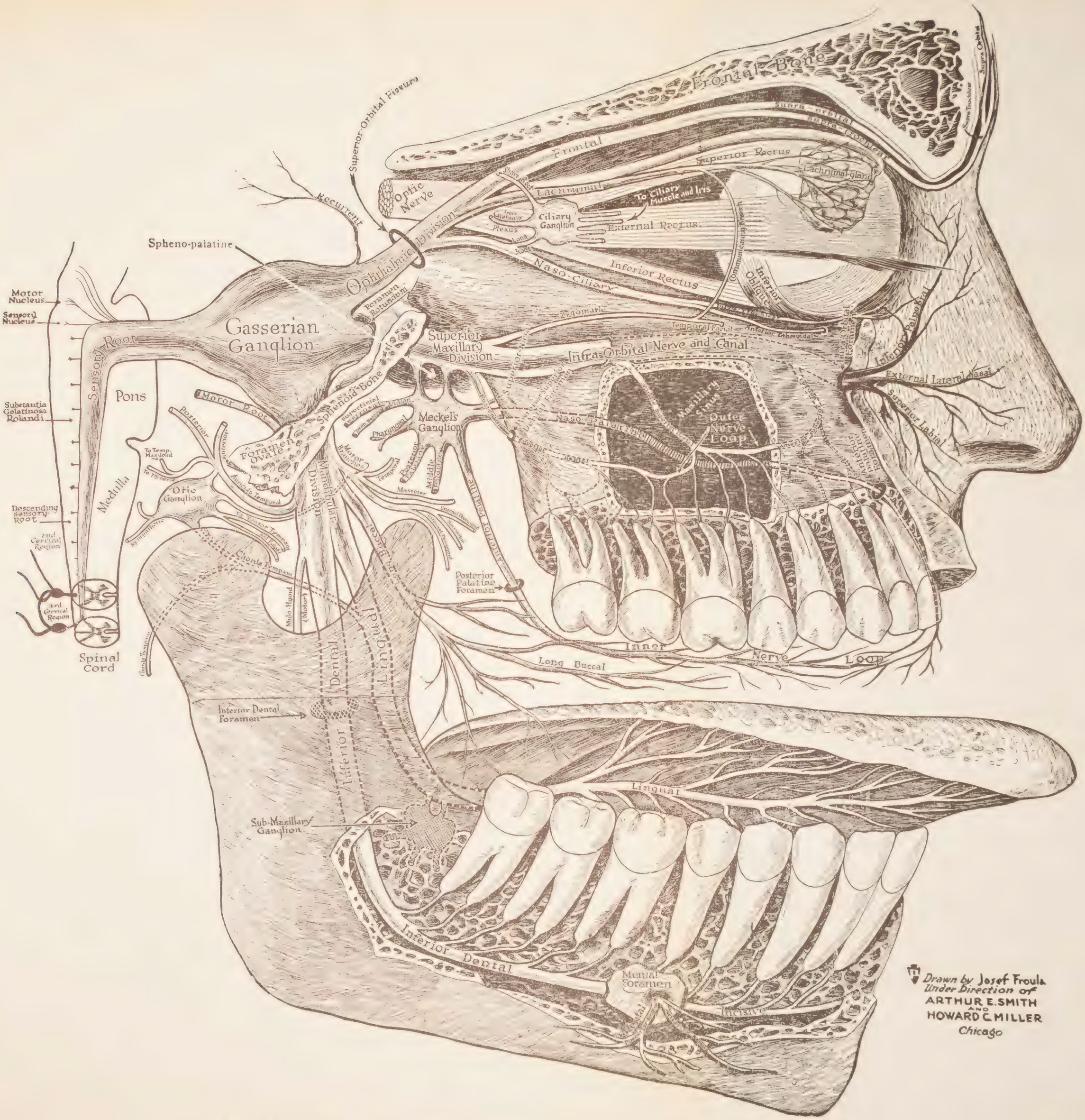


Fig. 12.—Schematic drawing illustrating the nervus trigeminus and the anatomic structures supplied by its branches.

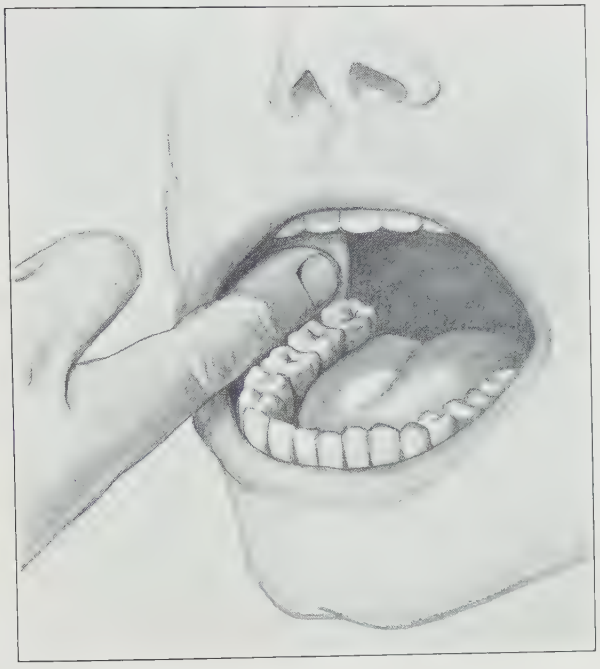


Fig. 14.—The ball of the finger resting in the retromolar fossa.

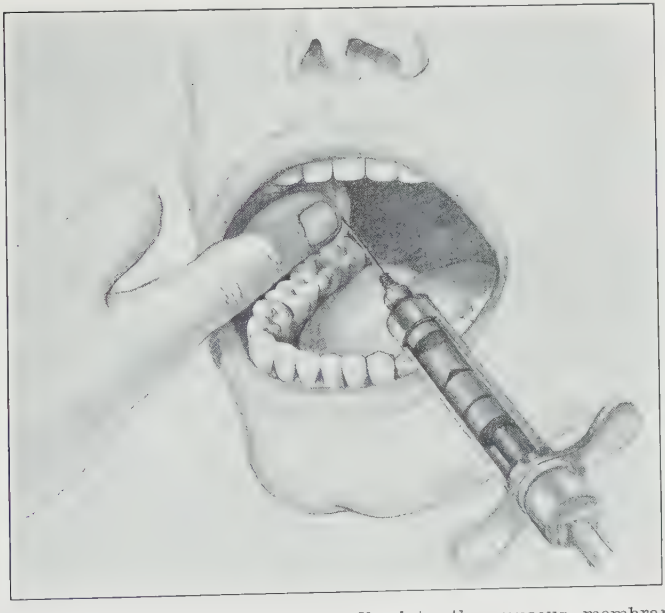


Fig. 15.—Point of penetration of the needle into the mucous membrane for the mandibular injection.

buccally and lingually; for the upper jaw a 1 or 1.5 per cent solution of novocaine, depending upon the age and general condition of the patient, and for the lower jaw a 1.5 per cent solution should be employed. The injection should be made very slowly. Rapid injections will be likely to result in a swelling or distention of the mucous membrane, incomplete anesthesia, and the possible incidence of untoward symptoms.

Fig. 16.—Injection of the left mandibular nerve. The left index finger is placed in position with the ball of the finger resting in the retromolar fossa. The left arm is held aside to avoid obstructing the view of the injection. A syringe is held with the pen grip at a point approximately 1 cm. above the occlusal surface of the molar. The technic of the injection is the same for the right side.

Mandibular Injection (Intra-Oral)

The blocking of the inferior dental nerve at the lingula on the inner border of the ramus will secure anesthesia of the particular side of the mandible, anteriorly up to the lateral incisor. If

anesthesia is desired in the anterior portion of the mouth or if the area to be operated upon extends to the midline, then anesthetization of the opposite jaw should be done via the inferior dental nerve, or infiltration of the mucous membrane alongside or slightly posterior to the anterior portion of the mouth should be employed.

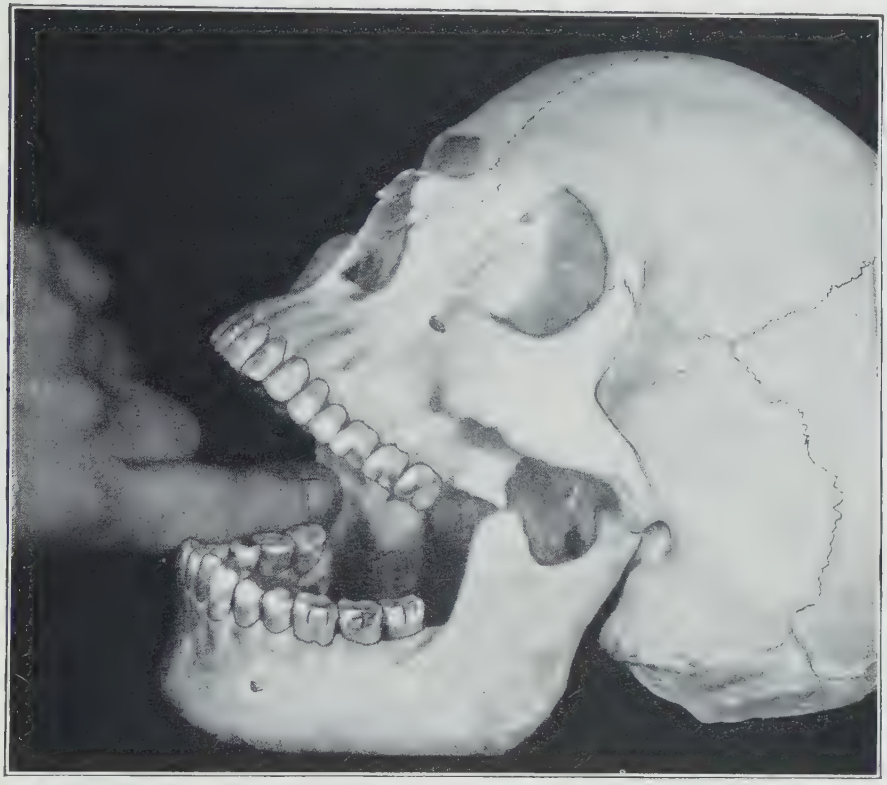


Fig. 17.—Radial side of index finger resting upon occlusal surfaces of lower teeth. Tip of finger resting over retromolar fossa; end of finger nail over internal oblique line with dorsal surface turned towards median line. (Smith—*Block Anesthesia and Allied Subjects.*)

This procedure is necessary because, while there never is any anastomosis between nerve fibers, there may be an interlacement of nerves from opposite sides, all of which should be anesthetized in order to secure perfect anesthesia.

The technic of injection of the right mandibular nerve is as follows: have the patient's head in an almost vertical position,

with the mouth open to the fullest extent. Place the index finger posterior to the third molar where a sharp ridge will be felt. This is the external oblique ridge of the ascending ramus. Directly lingually to this ridge is a groove called the retromolar fossa which the ball of the finger should reach. This accomplished, the finger nail automatically touches the internal

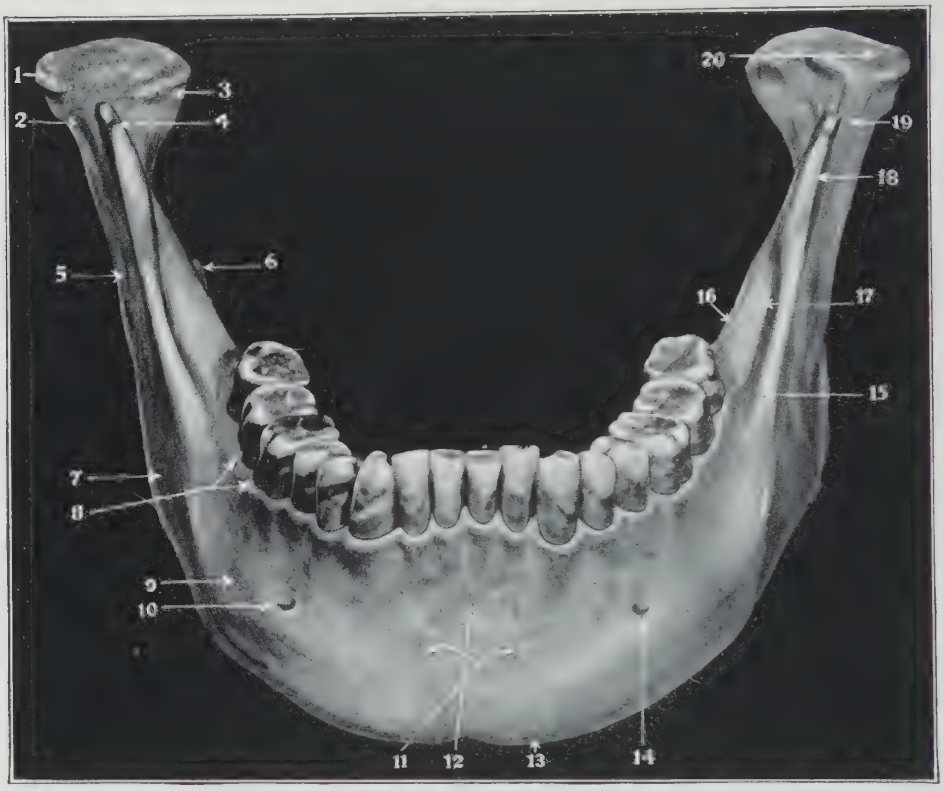


Fig. 18.—The mandible or inferior maxillary bone. (Anterior.) (Smith—*Block Anesthesia and Allied Subjects.*)

1, Condyle; *2*, neck; *3*, pterygoid depression; *4*, coronoid process; *5*, ramus; *6*, lingula; *7*, angle; *8*, alveolar border; *9*, body; *10*, mental foramen; *11*, incisive fossa and foramina of mandible; *12*, symphysis; *13*, mental tubercle; *14*, mental foramen; *15*, external oblique line; *16*, internal oblique line; *17*, retromolar fossa; *18*, coronoid process; *19*, sigmoid notch; *20*, head of condyle.

oblique ridge. The finger is kept in this position. Sterile gauze, by means of thumb forceps, is carried to the point where the finger tip rests, and the mucous membrane in this ridge, which is to be the site of puncture, is thoroughly dried. Aconite and iodine, by means of an applicator, are now carried to the same

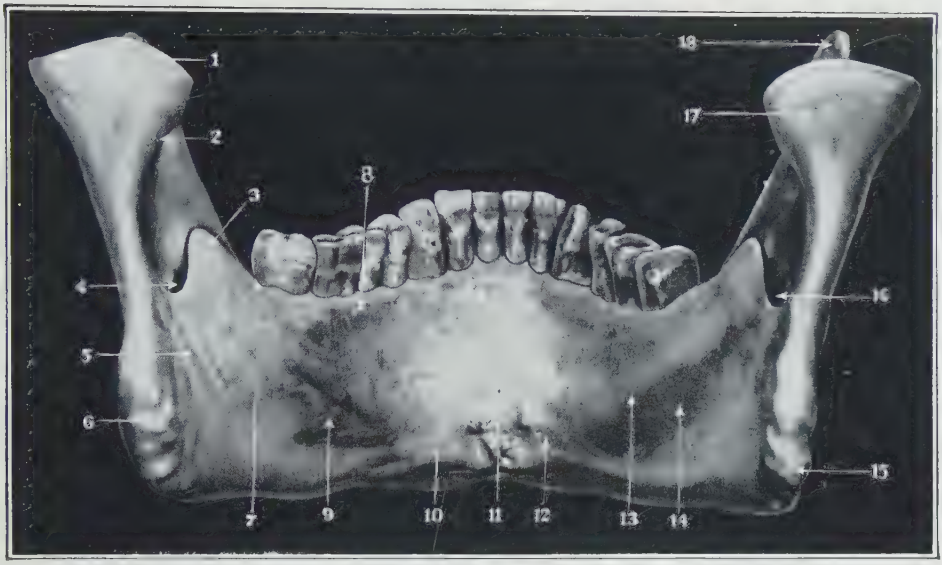


Fig. 19.—The mandible or inferior maxillary bone. (Posterior view.) (Smith—*Block Anesthesia and Allied Subjects.*)

1, Condyle; *2*, neck; *3*, lingula; *4*, mandibular foramen; *5*, mylohyoid groove; *6*, pterygoid tuberosity; *7*, internal oblique line; *8*, alveolar border; *9*, submaxillary depression; *10*, sublingual depression; *11*, geniotubercles; *12*, digastric fossa; *13*, mylohyoid ridge; *14*, submaxillary depression; *15*, angle of ramus; *16*, mandibular foramen; *17*, condyle; *18*, coronoid process.

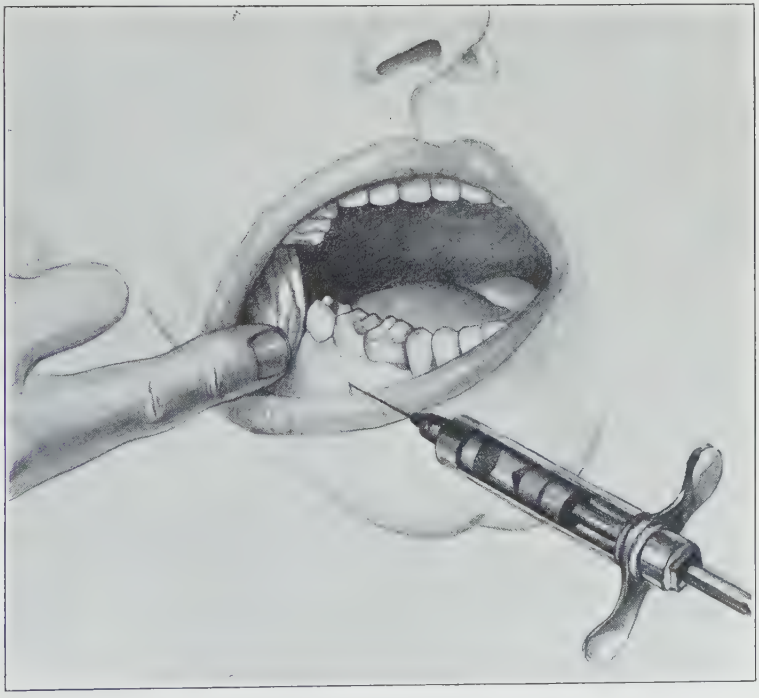


Fig. 20.—Point of injection for anesthetizing the long buccal nerve.

region, and a syringe, having the bevel edge of the needle toward the bone resting between the first and the second bicuspids of the opposite side, is brought into position. The needle, which should be made to penetrate the mucous membrane at a point approximating the middle of the finger nail, is then passed along the inner border of the ramus until the resistance of the bone to the needle is lost. Thereafter, the needle is passed over the lingula, the sharp prominence guarding the orifice of the inferior

Fig. 21.—*1*, Outline which shows the area anesthetized by blocking the posterior-superior dental nerve. *2*, Posterior-superior dental foramen. (Smith—*Block Anesthesia and Allied Subjects.*)

dental canal, and the solution is deposited by aid of a slight pumping motion. The motion is employed to infiltrate the areolar tissue around this nerve trunk, as it is never necessary to penetrate the nerve directly. If the solution is deposited above the lingula, the areolar tissue will conduct the novocaine to the nerve.

The anesthetization of the left mandibular nerve is accomplished by placing the index finger of the right hand in the position described above, with the syringe held in the left hand;

this assumes ambidexterity. I believe that injection with the right hand for the left side may be accomplished with a little practice and perseverence. The index finger of the left hand is placed in position in the retromolar fossa, the finger nail reaching the internal oblique ridge, and the syringe is held with the right hand resting upon the occlusal surface between the first and second bicuspid teeth.

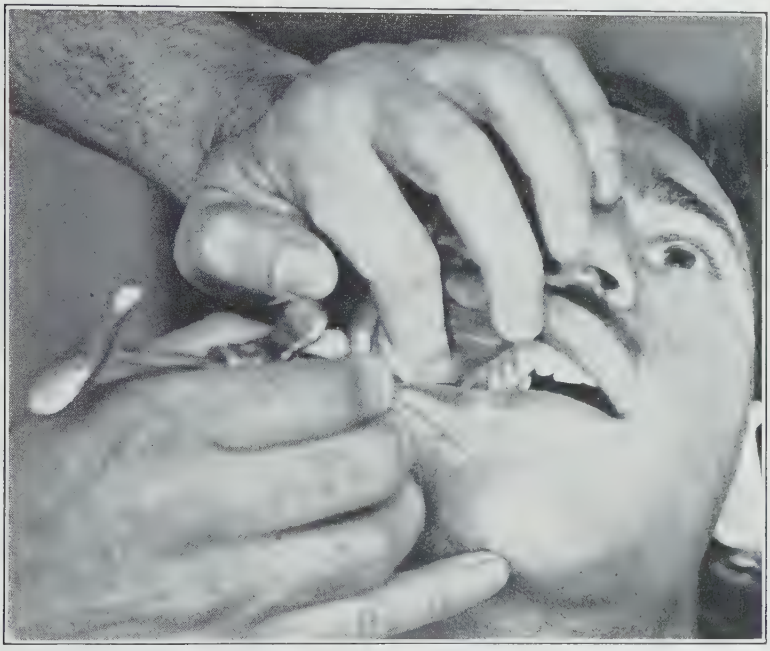


Fig. 22.—Position for the injection of the right posterior-superior dental nerve. The index finger of the left hand is placed under the zygomatic process. Mouth opened half way. The syringe is held with the pen grip, a 42 mm. needle is used, with the beveled edge toward the bone. With the syringe held at right angles to the bone, the mucous membrane is penetrated at a point approximating the apex of the distal root of next to the last molar in position. The needle is then directed upward, slightly backward and inward, until the hub is a slight distance from the mucous membrane.

If, after from ten to twelve minutes,—the normal time for producing anesthesia in the mandible—it is found that the patient has a tingling sensation of the particular side of the lip and tongue, but an absence of anesthesia in the molar region buccally, then an injection between the first and second molars should be made buccally for the purpose of anesthetizing the long buccal nerve.

Posterior-Superior Dental Injection (Tuberosity Injection).—For the anesthetization of the area occupied by the three molar teeth in the upper jaw, the posterior-superior dental injection, augmented by anesthesia of the mucous membrane of the lingual

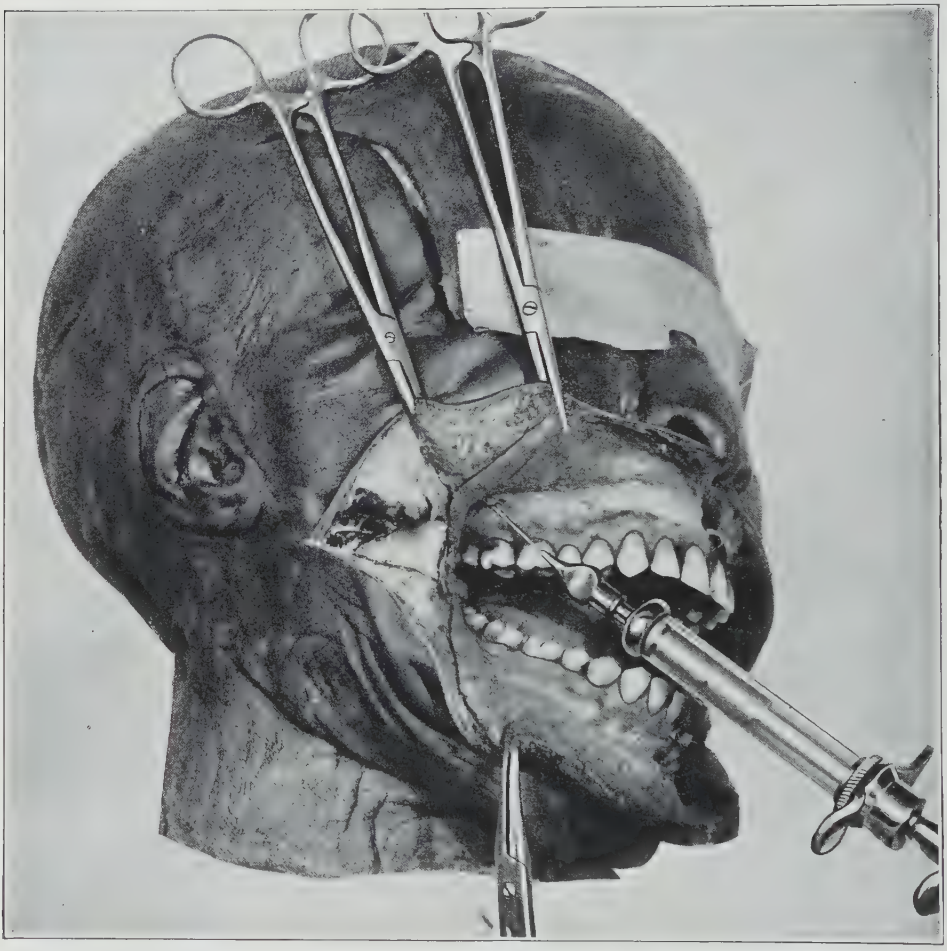


Fig. 23.—Illustrating the puncture point for blocking the posterior-superior dental nerve. The needle enters the reflection of the mucous membrane buccal to the distobuccal root of the upper second molar. (Smith—*Block Anesthesia and Allied Subjects.*)

aspect, either by way of the posterior palatine foramen or by a simple injection of the mucous membrane on the lingual surface of this area, will accomplish the desired result.

When it is expected that the area of operation will include or

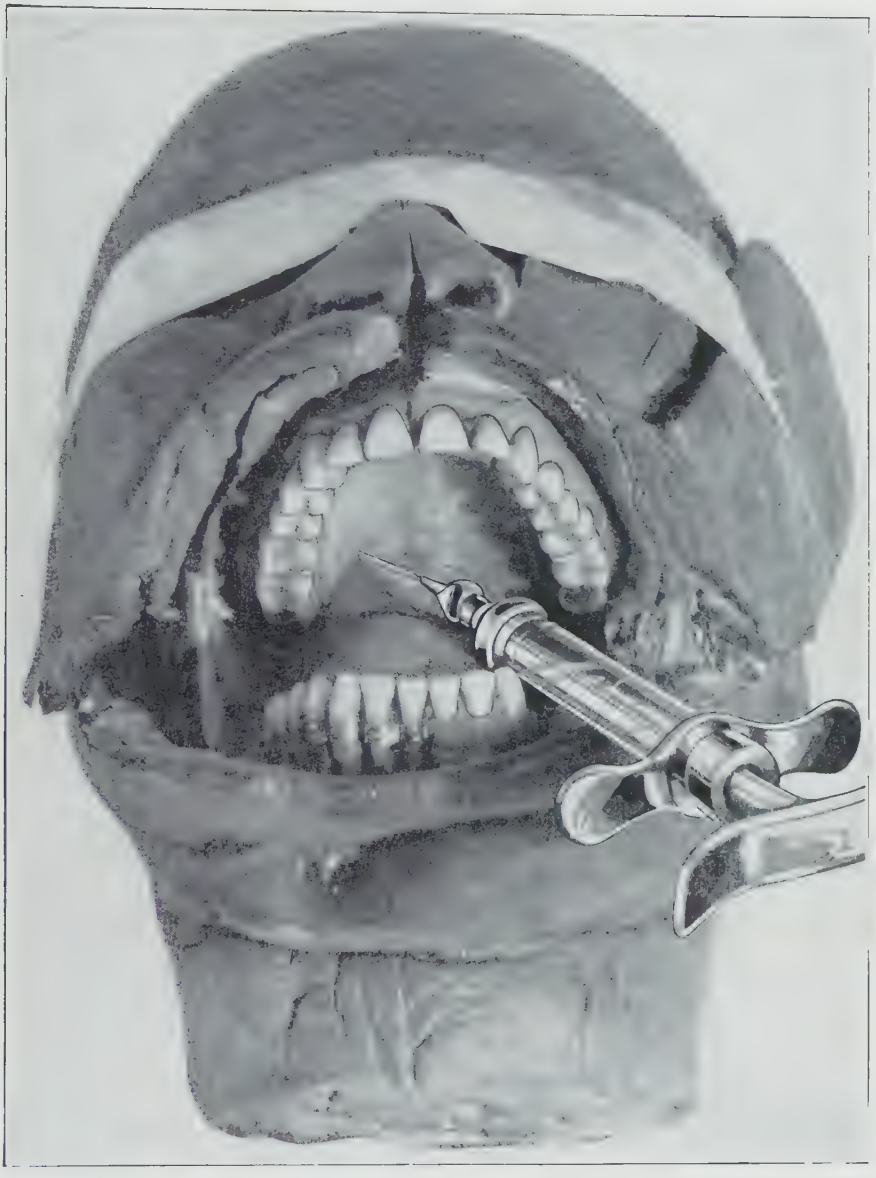


Fig. 24.—Position of syringe and needle while discharging the solution at the posterior palatine foramen for blocking the anterior palatine nerve. (Smith—*Block Anesthesia and Allied Subjects.*)

extend beyond the first molar, then in addition to the posterior-superior dental injection, the mucous membrane infiltration of the second bicuspids should be done for the reason that there

may be an interlacement of the nerve fibers of the middle superior dental nerves in this particular area.

The technic is to place the finger under the zygomatic arch, holding the syringe as one would hold a pen, and inserting the needle at a point approximating the apex of the distal root of the next to the last molar in position, directing the needle upward, backward, and inward, here again using the pumping

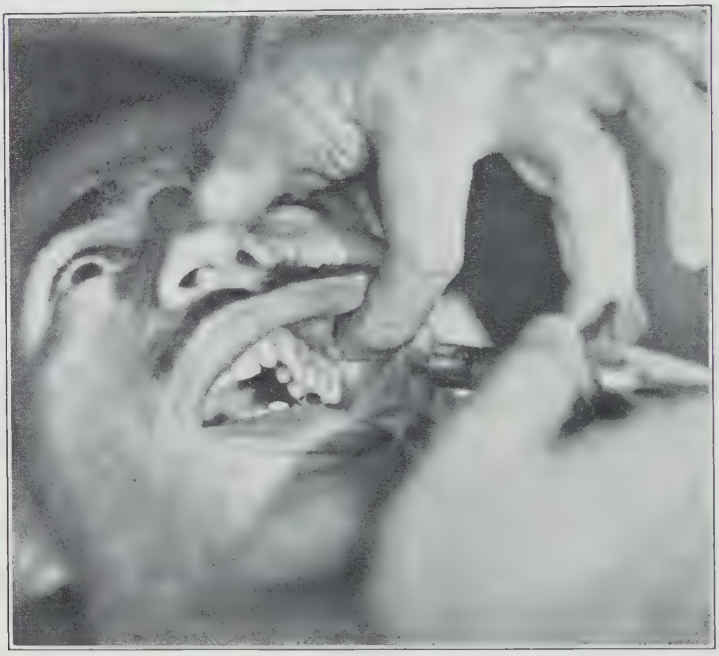


Fig. 25.—Position for the injection of the left superior dental nerve. Place left arm around patient's head, with the index finger of the left hand under the zygomatic process. Mouth is opened half-way. The syringe is held with the pen grip, a 42 mm. needle is used, with beveled edge toward the bone. With the syringe held at right angles to the bone, the mucous membrane is penetrated at a point approximating the apex of the distal root of next to the last molar in position. The needle is then directed upward, slightly backward and inward, until the hub is a slight distance from the mucous membrane.

motion in order to infiltrate the areolar tissue around this particular trunk.

The branches of the anterior palatine nerve, which pass through the posterior palatine foramen, may be reached by inserting the needle at a point slightly above the alveolar process on the lingual aspect, between the last molar and next to the last molar in position. The total quantity of novocaine for both of these injections should not exceed 2 c.c., 1.5 c.c. for the pos-

terior-superior dental injection, 0.5 c.c. for the posterior palatine injection.

The technic for injecting the upper left molar area necessitates having the left arm around the patient's head, the index finger under the zygomatic arch, and the same procedure followed as outlined for the injection of the right posterior-superior dental nerve.

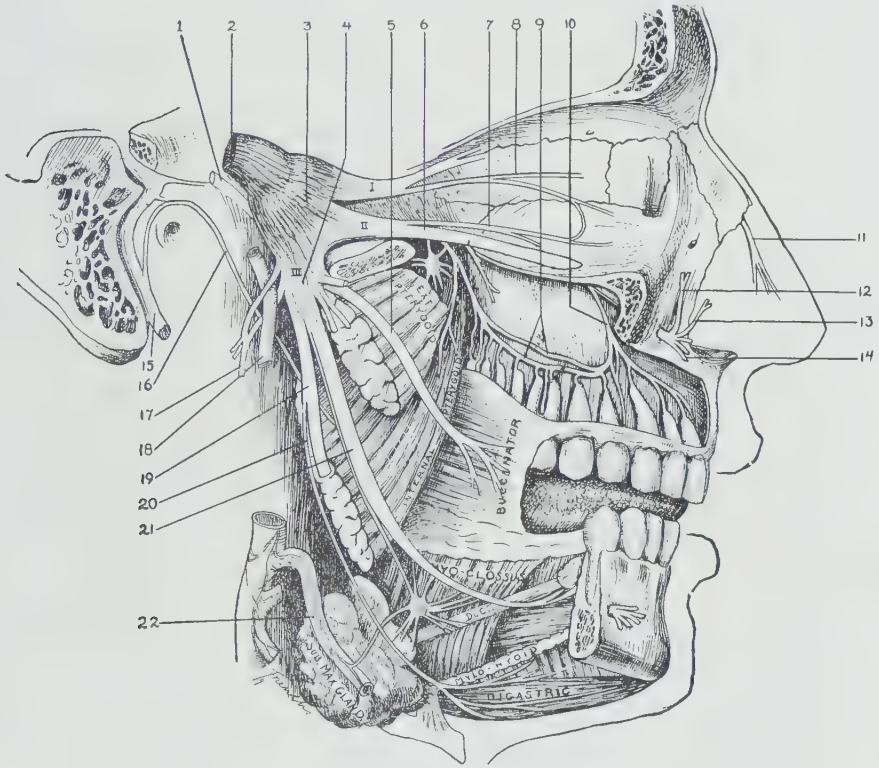


Fig. 26.—*1*, Motor root; *2*, sensory root; *3*, Gasserian ganglion; *4*, inferior maxillary; *5*, buccal nerve; *6*, superior maxillary; *7*, orbital nerve; *8*, lachrymal nerve; *9*, middle and posterior dental nerve; *10*, anterior dental; *11*, terminus of nasal nerve; *12*, palpebral; *13*, nasal; *14*, labial; *15*, facial nerve; *16*, chorda tympani; *17*, auriculotemporal nerve; *18*, middle meningeal artery; *19*, inferior dental nerve; *20*, mylohyoid nerve; *21*, lingual nerve; *22*, facial artery. (Retouched from Gray.)

Care should be taken in making this injection to retract all the tissues and at all times to hold the needle with the beveled edge toward the bone. This will avoid the danger of injecting the solution in the soft structures of the cheek, causing possible formation of a hematoma or of ecchymosis (an extravasation of the venous blood into the interstices of the tissues).

Mental Injection

This injection, in my opinion, is one which can be discarded for the reason that the desired result can readily be obtained

Fig. 27.—Showing the relationship of the needle and the anterior surface of the superior maxillary bone. The needle does not strike the periosteum until the region of the foramen is reached. The needle bridges the cuspid fossa. (Smith—*Block Anesthesia and Allied Subjects.*)

through use of mandibular injection which is more certain as to results and is simpler of administration.

The bicuspid area is best anesthetized by the infiltration method, inserting the needle midway between the gingival margin and the apex of the teeth.

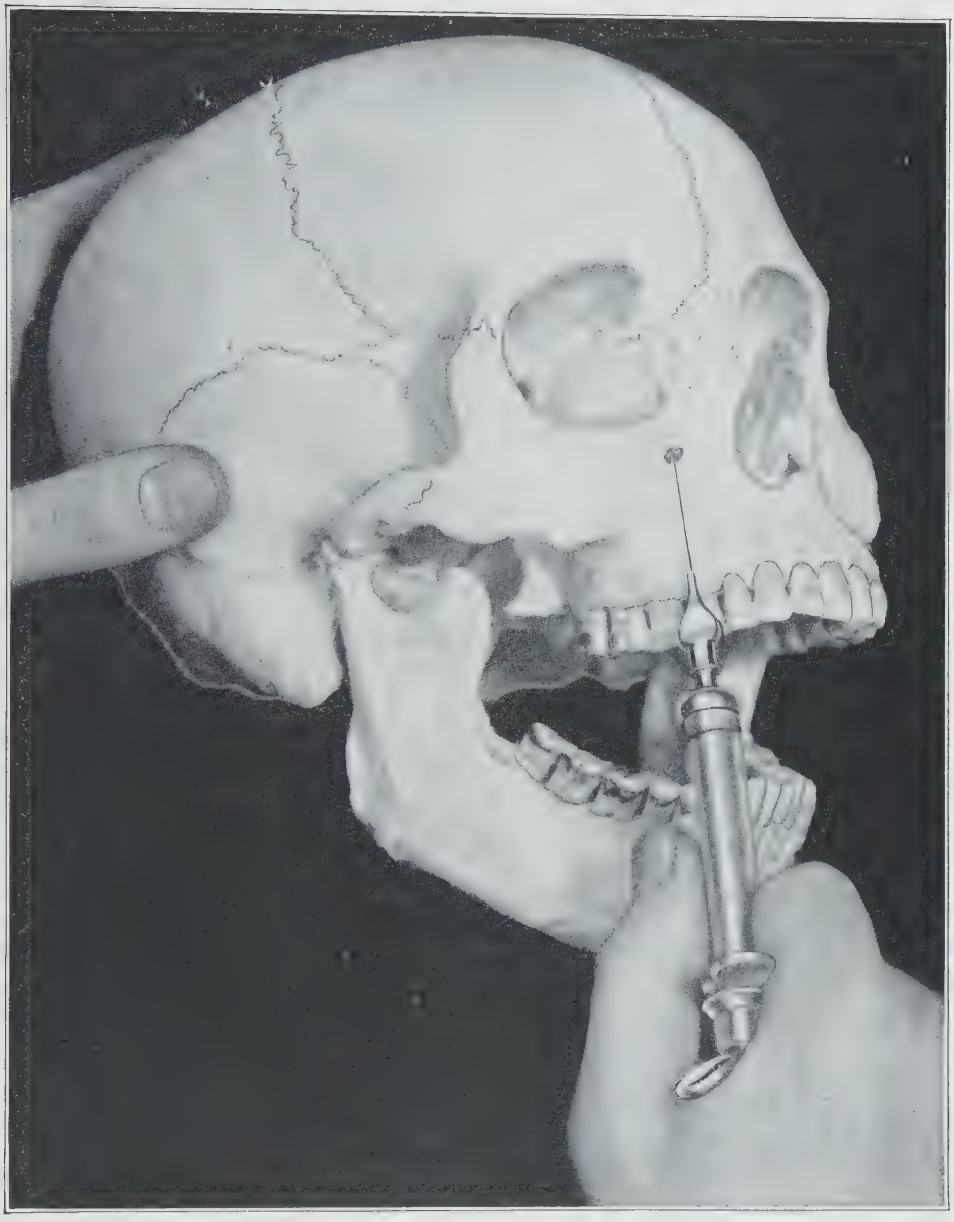


Fig. 28.—Illustrating the needle in region of the infraorbital foramen. Needle is held parallel to long axis of second bicuspid. (Smith—*Block Anesthesia and Allied Subjects.*)

Fig. 29.—The infraorbital injection. First position: The index of the left hand is used to palpate the supraorbital notch. The thumb is used to palpate the infraorbital foramen which is in a direct line with the supraorbital notch.

Fig. 30.—Infraorbital injection. Second position: The thumb is kept in position over the infraorbital foramen and the lip is everted with the left index finger. The syringe is held with the pen grip, the bevel edge of the 42 mm. needle toward the bone, and inserted in the deflection of the mucous membrane slightly above the apex of the first bicuspid tooth, keeping the needle a slight distance from the bone, passing upward and slightly backward until the needle is felt under the thumb.

Infraorbital Injection for Anesthetization of the Upper Central Lateral Canine.—The majority of textbooks, in describing the technic of this injection, advise the palpation, externally, of the

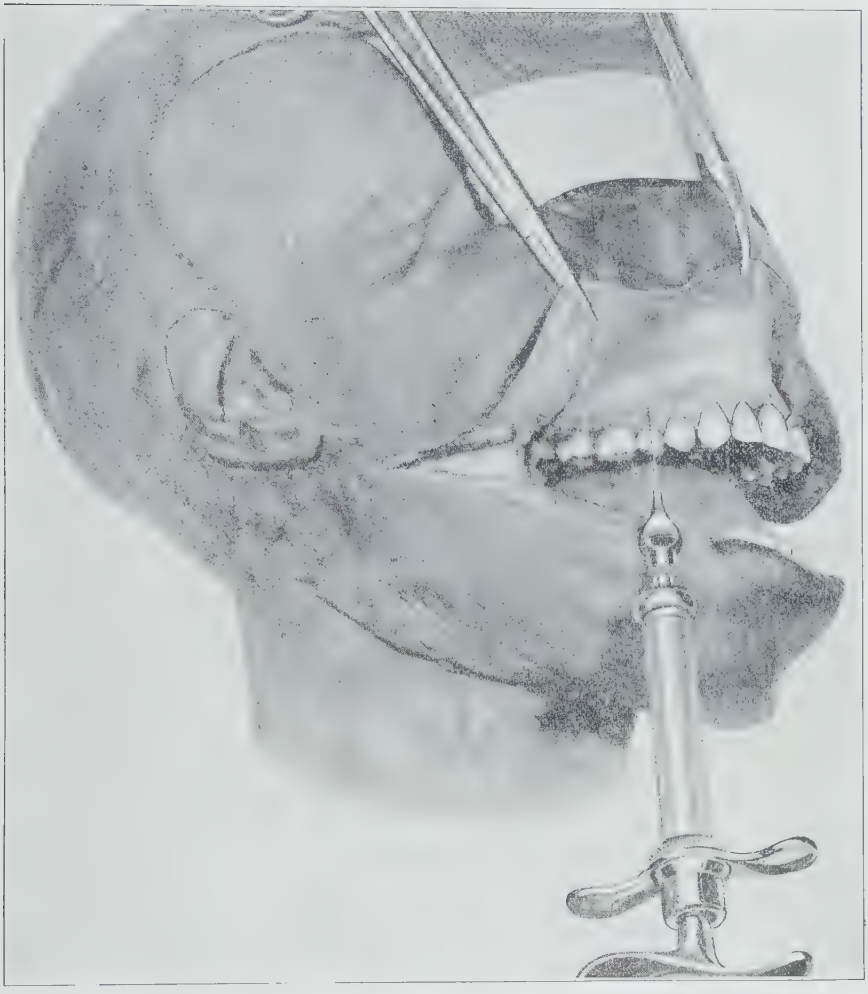


Fig. 31.—Wet anatomic specimen illustrating the starting point of the needle for blocking the anterior-superior dental, infraorbital nerve and branches at the infraorbital foramen. Needle is started in the mucous membrane buccal to apex of second bicuspid. (Smith—*Block Anesthesia and Allied Subjects.*)

infraorbital foramen. This, in my opinion, can be accomplished in but very few cases.

The index finger of the left hand is used to palpate the supraorbital notch which is in a direct line with the infraorbital fora-

men. The thumb of the same hand is then placed over the area approximating the position of the infraorbital foramen. The lip is inverted with the index finger, and the needle is inserted into the reflection of the mucous membrane at a point distally to the canine tooth, and it is carried upward and backward, until the point of the needle may be felt beneath the thumb. A maximum

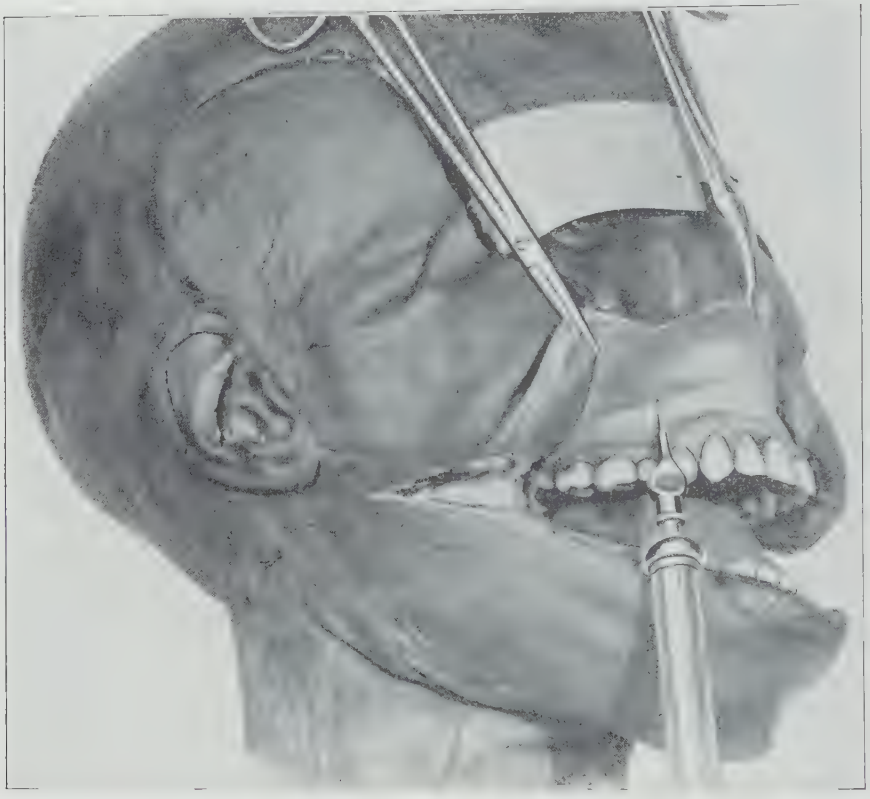


Fig. 32.—Position of the needle while the point is in contact with the periosteum near the infraorbital foramen. Approximately two centimeters of the needle are inserted in the tissue while one centimeter is located exterior to the puncture point. (Smith—*Block Anesthesia and Allied Subjects.*)

of 1 c.c. of solution is then deposited with a slight pumping motion and the needle is carefully withdrawn. Light massage of the face in this particular region often aids in hastening the anesthetic effect. The second method of approach of the infraorbital foramen is the so-called "Sicher technic," in which the needle is inserted approximately at the apex of the central incisor and is directed upward and distally to the foramen.

The posterior palatine injection is used for the purpose of anesthetizing the lingual surface of the mucous membrane of the three upper molars. It is reached by inserting the needle at a

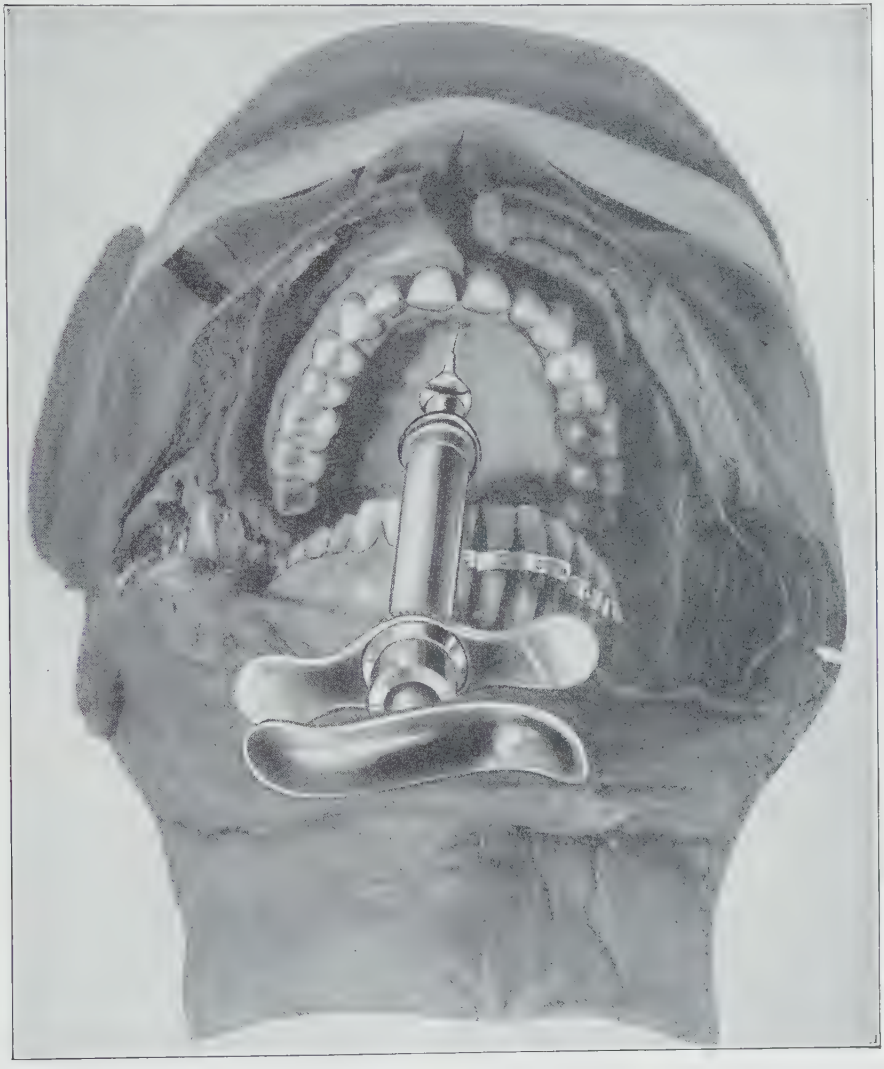


Fig. 33.—Syringe in position for discharging solution at anterior palatine foramen for blocking nasopalatine nerves. (Smith—*Block Anesthesia and Allied Subjects.*)

point slightly above the alveolar process between the last molar and the next to the last molar in position.

The anterior palatine injection is used to anesthetize the lin-

gual surface of the upper jaw from canine to canine. One-half cubic centimeter of novocaine solution will be sufficient to bring about the desired anesthesia. The patient's head should be turned back as far as possible. The tissues are punctured to one side of the median line, and distal to the rugae. The syringe should be held with the "pen grip," with the barrel resting upon the lower central incisor.

CHAPTER XIII

ACCIDENTS AND INFECTIONS FOLLOWING LOCAL ANESTHESIA

Within the last few years reports of accidents and of infections following local anesthesia have been on the increase. Were a more careful history and physical examination of the patient made, it would be found that the majority of these cases were really dormant abscesses which were operated upon during the second stage of their progress and that they reached the third stage only after the extraction of the offending tooth. It must be clearly borne in mind that the removal of a tooth does not necessarily clear up the abscessed condition. It is of the utmost importance that a careful diagnosis be made, for if the report gains ground that the use of novocaine causes accidents and infections, its employment will be restricted and that will indeed be a sad day for the profession.

That there should be an increase in the number of accidents and infections following the use of novocaine is a natural outcome of its employment by an increased number of inexperienced operators. The fact that twenty years after its introduction, novocaine has found its way into every important clinic and is in general use, practically superseding all other soluble and local anesthetics, is sufficient testimony to its value in therapy. This obvious conclusion is confirmed by strict scientific comparisons of all the proposed anesthetics by authorities who have published their results from time to time. Braun, Fischer and Le Brocq, of the Therapeutic Commission of the British Medical Association on local anesthetics, recommended novocaine as a substitute for cocaine after a comparative study of stovaine, novocaine, tropacocaine, eucaine-B, alypin, holocaine, acoin, arthoform, anesthesin and cocaine.

Novocaine has also been condemned because of a few cases of dermatitis on the hands of some operators. Circumstantial evidence seems to trace the condition directly to the use of this drug, for the discontinuance of its use has resulted in the disappearance of the malady.

The presence of novocaine on the operator's hands is due to one of two conditions. A faulty armamentarium or a faulty technic. Phenol, too, would be a detrimental agent on our hands, yet when properly used it is an invaluable therapeutic agent.

The causes of infection following injection may be divided into five groups as follows:

1. *Faulty technic,* such as injection on the lingual surface of lower third molars, particularly in cases of pericoronal infections. Injections into the soft structures in the attempt to anesthetize the posterior-superior dental nerve (the tuberosity injection).

The operator should be careful to take the proper precautions with reference to properly sterilizing prior to the initial injection. If on quizzing the patient for the symptoms of anesthesia or on testing for it, a particular area is found unanesthetized, and an additional injection is made without the proper preparation of the surface, and should this injection be made on the lingual surface of a third molar where there is pus present, some of the purulent material may be forced down into the deeper structures and an infection is sure to follow. This would result regardless of the substance used, whether novocaine or water. This region is a particularly dangerous one, for it will be found upon dissection that directly posterior to the third molar on the lingual aspect there is a space which contains little but connective tissue. This space is not described in any textbooks on anatomy, so for the sake of convenience we shall call it the retropterygoid space. If an instrument is inserted in that space, it will come directly on the outside of the face. Should purulent material be forced into this space, an infection which will rupture externally is very likely to result.

Injections on the lingual surface of third molars should be discouraged, unless they are imperative, not only because of the danger of causing infection, but also because of a possible injury to the lingual nerve. To quote Fischer: "The lingual nerve, owing to its superficial situation under the lingual mucosa, may be endangered by contusions during extraction of lower molars, also by local injections. In lean patients this

nerve may be seen through the thin covering of mucous membrane. In one case the lingual nerve trunk together with fibers of the accompanying chorda tympani was severed by incision of a lingual abscess of a lower third molar, resulting in loss of sensation in the tongue on the injured side. As a consequence, the patient, female, lost her sense of orientation regarding the position of the tongue in the mouth, resulting in loss of coordination of the otherwise sound lingual muscles. No improvement resulted from treatment with the galvanic current.

"In another case, the patient, aged fifty years, experienced suddenly an intense pain lingually to the third molar, while being injected locally. Numbness on that side of the tongue rapidly ensued. The following day serious trismus supervened, together with necrosis of the soft tissue extending to the region of the ascending ramus of the mandible. After nine months, the numbness on the left side of the tongue persisted, speech was seriously impeded, and the tongue had a tendency to slip between the posterior teeth, though taste was not impaired.

"From these cases it appears imperative to refrain from injections at the lingual side of lower molars, especially to keep away from the floor of the mouth. The sensory lingual nerve is endangered even in extractions of third molars, as has been shown by Roser and Trauner. In a young lady, the removal of both lower third molars was followed by neuralgia of the lingual nerve on both sides, which was attributed to contusions of the nerve within the socket."

If the authorities agree that it is dangerous to inject on the lingual aspect of third molars under normal conditions, then to inject in this area in cases of pericoronitis, where pus is present, is certainly contraindicated.

2. *Septic Instrumentation.*—This includes the injudicious use of syringes and solutions. No operator would willfully use a septic needle; however, he might overlook the fact that his patient could become infected if he used the same needle a second time, improperly. For example, a quantity of novocaine sufficient for a particular case has been prepared. The solution is drawn up into the syringe and an injection is made. Should more of the anesthetic be required, the thoughtless operator may again insert the needle in the crucible and draw up more of the

solution. It is possible, however, that some bacteria which in the initial injection may have adhered to the surface of the needle will be drawn into the solution and injected into the tissues. The remedy for this condition is to use a different sterile needle for each separate injection. Those who content themselves with merely wiping off the once-used needle with sterile gauze, are not satisfying the requirements, even though they may never have experienced difficulties in this connection.

Another species of remissness is the sterilization of the needle in the common instrument sterilizer. As a general rule, some substance is placed in the sterilizer to prevent instruments from rusting. This material may enter the lumen of the needle and contaminate the solution.

3. *Injections into Muscles.*—It is essential, in making a mandibular injection, that the inner border of the ramus be palpated with the needle before proceeding farther. A simple technic is to have the patient's head in an almost vertical position, with the mouth open to the full extent, then with the index finger of the left hand to palpate a sharp ridge running at right angles to the body of the mandible at the angle, which we know to be the external oblique ridge. Just lingually to this ridge a groove can be felt in which the ball of the finger is rested, and the inner border of this groove is the internal oblique ridge. The operator proceeds to inject, holding the syringe on the opposite side of the mandible and inserting the needle in the mucous membrane at approximately the middle of the finger nail when the internal oblique ridge is reached. If one fails to strike bone the needle should be withdrawn and again introduced, since if proceeding as primarily attempted, injection may be made in the superior constrictor of the pharynx; infection of this muscle may result in the formation of a retropharyngeal abscess.

4. *Use of a too Concentrated Solution.*—The gauges on some of the porcelain crucibles are faulty. Some are marked to contain 10 c.c., when they contain but 8 c.c. In such a case a hypertonic solution stronger than 2 per cent would be used.

5. Infection due to carrying bacteria on the needle from the saliva or tissues, because of *improper preparation of the field.*

It is not uncommon for an operator to paint the tissues with iodine where he anticipates inserting the needle and then to insert the needle at some other point where there is no iodine. It is important to make sure of the location of the injection and then to prepare that particular field.

When an abscess is suspected in a region which has not been directly injured, careful search should be made for the original focus of infection; and it should not be forgotten that the intervening tissues may show no evidence of disease. It is an established fact that an infection from a wound of the mouth may spread to the areolar tissue of the neck and there cause cellulitis and suppuration without giving signs of inflammation in the tissues of the floor of the mouth through which it passed. As the pus within the abscess accumulates, by progressive liquefaction necrosis of the surrounding layer of lymph, the size of the abscess increases. It spreads most rapidly in the direction of least resistance,—in these particular infections toward the skin surface of the neck.

In cases where an infection is suspected and the characteristic symptoms are absent, the possibility of suppuration deeply seated must be kept in mind.

The experienced touch of the surgeon may enable him to proclaim with certainty the presence of pus, when to one not possessed of the *tactus eruditus* a positive diagnosis would be impossible.

Diagnosis.—It is not likely that an acute, superficial abscess, already pointing, will be mistaken for anything else. However, there are many other affections with which an abscess at times may be confused. Careful and systematic examination of the patient should therefore never be neglected. It is just as important for the operator, in looking for the symptoms of an abscess, to scrutinize the lingual aspect of the jaw as the buccal or external surface.

Symptoms.—The symptoms of an infection following an injection of the structures on the inner border of the ramus or of the floor of the mouth manifest themselves between one and ten days following the injection. They may be enumerated as follows:

1. Partial or complete trismus.
2. Intermittent elevation of temperature.
3. Pain.
4. Swelling in various degrees, depending on the duration of the infection.
5. Sleeplessness.
6. Difficult deglutition.

The usual history is that the patient had a tooth extracted two or three days previously. The day following the extraction there was difficulty or inability to open the mouth to the full extent. A visit to the dental surgeon brings forth the information that the condition is perfectly all right,—just due to trauma —and after a mouth-wash has been advised, the patient is usually dismissed. Most patients, unless extremely nervous or if the symptoms become alarming, will usually wait a few days for the condition to clear up. If it does not, they will return to the dentist, or, feeling at times that such symptoms are outside the sphere of a dental surgeon, they will apply to their physician for relief.

In upper jaw infections, the swelling and inflammation will be found to be entirely limited to the soft structures of the cheek, and not in those overlying the bone. It may be accompanied by ecchymosis. If the area presents definite symptoms of fluctuation, an incision should be made into the soft structures and proper drainage applied. Swellings in these cases may be very pronounced. At times there may be a swelling on one side, which may extend over to the other side, infecting both frontal regions and manifesting the symptoms of acute sinus disease.

Prognosis.—This is good in most cases, provided treatment is prompt and efficient. Lower jaw infections, which may arise, often develop into retropharyngeal abscesses.

Treatment.—When pus has once formed much may be done to ameliorate the symptoms and relieve the patient with as little disfigurement as possible. In all cases an effort should be made to prevent external rupture.

Hot saline irrigations every hour should be recommended to hasten the "pointing" process.

To relieve pain, anodynes may be administered internally.

In endeavoring to locate pus in the retropharyngeal region a blunt instrument should be used for the purpose of exploration. Another valuable instrument is a knife with a blunt point and sharp edge, the principle being to penetrate the pus bag with the blunt point and to enlarge the orifice of the wound by withdrawing the knife. The use of a pointed knife in this region may result in an irreparable injury.

After the abscess has been lanced internally and there appears to be evidence of its pointing externally, warm, moist heat in the form of a poultice should be applied. But though these adjuvants may be employed with advantage in certain cases, prompt evacuation of the pus by incision is much more efficient in checking pain by relieving tension and hastening the conversion of the abscess into a superficial ulcer. Moreover, the cicatrix resulting from a well-placed incision is much less disfiguring than one which occurs when an abscess is allowed to burst spontaneously. In most abscesses affecting the subcutaneous tissues it is better to postpone incision until fluctuation is evident and pointing has nearly occurred; but in other cases incision should be adopted much earlier, general or local anesthesia being employed as may seem indicated.

In opening an abscess in a dangerous neighborhood, such as in the region of the triangles of the neck, it is much safer to adopt Hilton's method of incising merely through the skin and superficial fascia and of then introducing a grooved director and burrowing down to the abscess with the latter or with blunt scissors; when the pus is reached the blades of the scissors are widely separated and the scissors are withdrawn, thus dilating the tract.

When an abscess has been opened it should be allowed to discharge its contents slowly. The operator may gently support its sides, to encourage the discharge of pus, but he should by no means attempt to expel it by massage, and most emphatically he should not introduce a curette into the abscess cavity to scrape away its lining membrane. Such a course destroys the granulation tissue surrounding the abscess cavity, may open neighboring venules or lymphatic radicles, and is extremely apt to cause a spread of the inflammation. When the tension of the abscess cavity is relieved by the evacuation of the pus its walls will col-

lapse. In the vast majority of cases it is important to introduce between the lips of the incision some substance which will keep them from uniting until healing of the underlying abscess cavity is complete.

Accidents following mandibular anesthesia with novocaine may be divided into three groups:

1. Injection of alcohol into the tissues.
2. Injury to the lingual nerve.
3. Breakage of needles.

1. The injection of alcohol in small quantities may give rise to a prolonged anesthesia, while the introduction of even a half centimeter may produce sloughing. Syringes which are suspended in a solution of two parts alcohol and one part chemically pure glycerine, when not in use, should be thoroughly cleansed with warm sterile water before being used.

2. The question of the injury to the lingual nerve has been heretofore discussed.

3. Needle break may occur even in the practice of the most experienced operator. However, my statistics seem to show that the great majority of these accidents occur in the hands of young practitioners. The usual causative factor of this occurrence, as set forth by the operator, is that the patient moved. While the reason assigned is undoubtedly true, we should not lose sight of the fact that the patient is not a dentist or a physician and, therefore, he sits there in apprehension, for he cannot conceive how the insertion of a long needle of that type will not cause excruciating pain or injury. Especially is this true if the operator explains to the patient that he is not going to inject around the tooth but is striving to reach a distant nerve. To expect a patient to sit quietly under such circumstances would be analogous to the condition described by Dr. George W. Crile:

"If one were placed against a wall and were looking into the gun muzzles of a squad of soldiers, and were told that there were nine chances out of ten that he would not be killed outright when the volley was fired, would it help him to be told that he must not be afraid? Such an experience would be written indelibly on his brain. This corresponds closely to the position in which some surgical patients are placed."

Cause of Accidents.—1. Lack of intimate knowledge of the structures. 2. Improper technic in making injections.

1. It is important to keep in mind that there are many and varied differentiations in the anatomic structure of human beings. The internal oblique line may be very prominent in one mandible and very indistinct in another. When the operator strikes the internal oblique ridge in making the injection, he should withdraw his syringe slightly and with his index finger push the needle alongside the bone and not try to force it through. Whenever he meets an obstruction he should cease operation and withdraw the needle.

2. The use of a steel needle, 23-gauge, will greatly minimize the danger of accidents but will not eliminate breakage. Platinum needles, when straightened after having been bent considerably, will be very weak at that particular point and will break readily. Safety guards on needles are but very little protection, for there is no guarantee on just which side of the guard the needle will break.

A good precaution is to use a 23-gauge steel needle and not insert it into the tissues up to the hub. To be certain, then, that the point of the needle passes over the lingula, that sharp prominence which guards the orifice of the inferior dental canal, I recommend a needle slightly longer than 42 mm.

Technic for Removing Broken Needles in Inner Border of Ramus.—Incisions for the removal of broken needles should always be made at right angles to the needle. Two radiographs, an anteroposterior plate and a lateral plate, should be taken in all cases. The anteroposterior plate will show the relative position of the needle to the inner border of the ramus. The lateral plate will show just how far anteriorly the posterior point of the needle may be or how high or low it is situated.

1. Seat the patient in the same position as for a mandibular injection, the head in an almost vertical position, with the mouth open to the full extent.
2. Anesthetize the area locally with novocaine.
3. Use a headlight.
4. Palpate for the internal oblique ridge.
5. Make an incision at right angles to the needle, slightly pos-

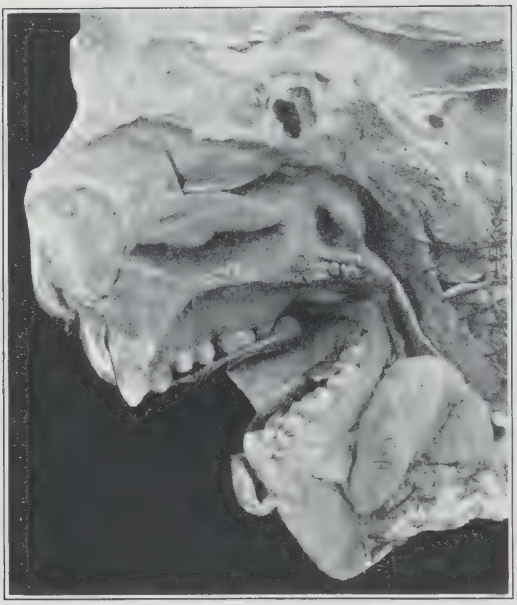


Fig. 34.—Showing method of making incision. Incision should be made one inch in length, at right angles to the needle, to a depth just through the mucous membrane, beginning the incision slightly posterior to the posterior end of the needle.

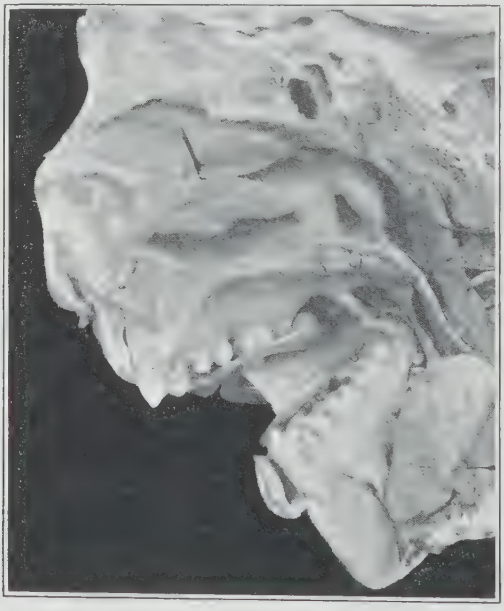


Fig. 35.—The buccopharyngeal fascia found directly beneath the mucous membrane.

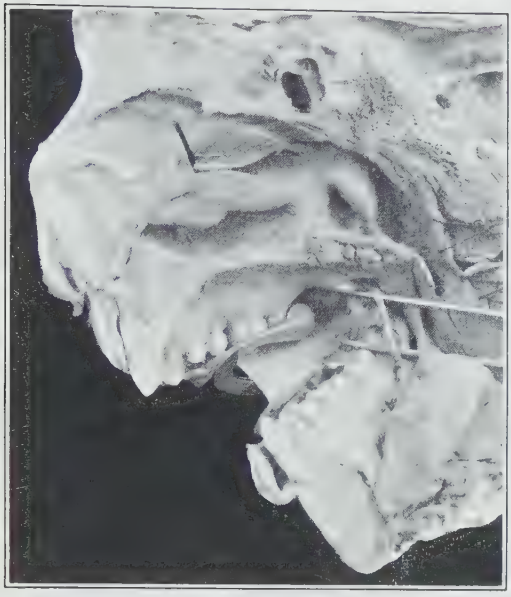


Fig. 36.—The lingual nerve, which may be grasped by placing a blunt hooked instrument into the opening and passing it downward toward the angle of the jaw and working upward. This important structure should be located and held aside to avoid its injury.

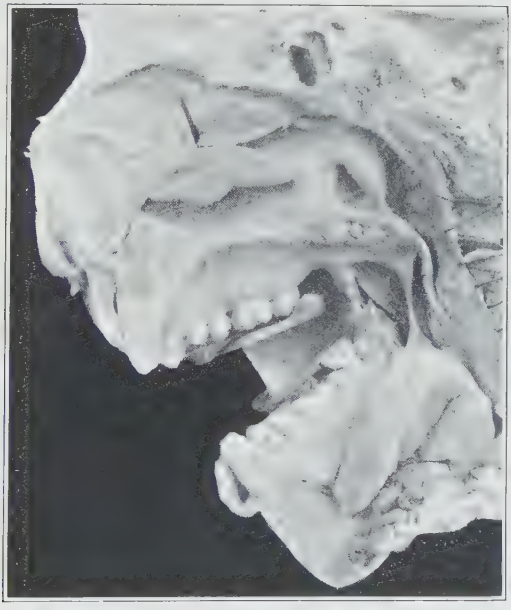


Fig. 37.—Showing the internal pterygoid muscle.

terior to the internal oblique ridge, cutting through the mucous membrane and the buccopharyngeal fascia, and with tissue retractors spread the lips on either side of the incision.

6. Cut through the superior constrictor of the pharynx. The fibers of the superior constrictor run in a horizontal plane. A surgical principle must be here violated in order to attain the goal.

7. If the needle has not been reached up to this time, place a hooked instrument in the wound and pass it down to the inner

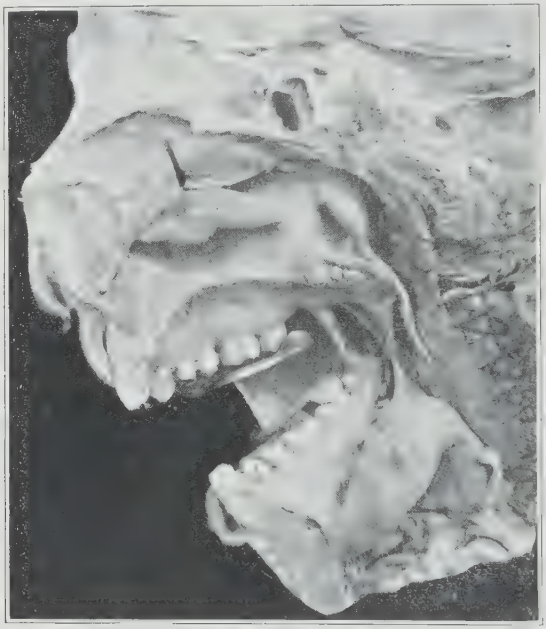


Fig. 38.—Showing the needle alongside the periosteum, covering the inner border of the ramus.

border of the angle of the jaw and lift up the lingual nerve, holding it aside with the retractor to prevent its injury.

8. Lift up the internal pterygoid muscle; do not cut it.

9. Remove the fascia carefully and thereupon you will strike the needle, for you are now in contact with the periosteum of the inner border of the ramus.

The structures on the inner border of the ramus, mentioned above, must be penetrated before the needle can be removed, provided the injection was properly made and the needle

lies along the periosteum of the bone. In cases where the needle extends beyond the anterior border of the ramus, an incision directly posterior to the third molar in the region of the retromolar triangle would be the best means of reaching it.

I believe that in every scientific paper there should be a full and candid presentation of our varied experiences—our mistakes and failures no less than our successes. This makes possible intelligent comparison, stimulates suggestions, and leads to discussion out of which each of us may gather something of profit.

Out of a total of eighty-four broken needle cases referred to, there were eighty-one successful operations. In each of the three failures the cause may be directly attributed to the effort to relieve the responsibility of the dentist and to the endeavor to remove the needle when there was trismus and edema to contend with. When a needle is to be removed, the attempt should be made immediately after the break or not until the trismus has disappeared, so that one can operate without the serious drawback of trauma. If it is felt that the needle should be removed immediately, even though trismus be present, operation should be performed under a general anesthetic.

Hematoma.—This condition is the result of an improper posteriosuperior dental injection, where the soft structures have not been properly retracted and in consequence of which the small blood vessels are punctured by the needle. This will result in the extravasation of blood into the interstices of the tissues with resultant discoloration and swelling. This complication may arise even though proper technic is employed.

The best treatment is the simple one of noninterference, assuring the patient that normal conditions are sure to follow shortly.

CHAPTER XIV

THE CONTROL OF BLEEDING IN ORAL SURGERY OPERATIONS*

Very few patients promptly inform us that they are "bleeders," or, in the recital of their histories, acquaint us with the fact, when such is the case, that several members of their family died from hemorrhage. The slightest injury suffices to occasion fatal bleeding in this type of patient; therefore all operative procedures so far as they are concerned must be limited as much as possible, and conducted only if life is in imminent jeopardy. Every case of hemorrhage must be regarded as potentially serious, inasmuch as one can never tell definitely, without preliminary tests, whether the patient has only a marked tendency to bleed or is a true hemophiliac. Very often patients state specifically that they bleed easily. However, dental surgeons do not commonly view such an admission as an indication of a serious possibility.

In this connection the history of a patient as reported by Moral is of interest. The case is that of a twenty-six-year-old clerk who recovered from an attack of typhoid fever at the age of twenty, and at twenty-two was treated for ten weeks for hemorrhages of the stomach. He said that he had repeatedly observed severe bleeding of the gums. The patient observed a pronounced swelling in the lower jaw, coupled with pain in or about a tooth. He consulted a dentist, informing him that he was a "bleeder"—information which his physician asked him to give whenever he consulted a physician or a dentist. Three days after the dentist removed the tooth, the hemorrhage having continued even though ferric chloride dressings had been applied,—a remedy that should not have been used under any circumstances—the patient was referred to a hospital for further treatment. The man appeared at the hospital, pale and undernourished. Blood flowed continuously from the empty

*Abstract of an article by Winter and Chas. G. Darlington published in the Journal of Dental Research, 1926.

alveolus. A tampon made of iodoform gauze was tried unsuccessfully. This was followed by applications of coagulin, both liquid and solid; then penghawar djambi,—all without result. On the following morning the patient received, intramuscularly, 40 c.c. of sterile solution of gelatin; a little later, 10 c.c. of a solution of sodium chloride intravenously. Notwithstanding these injections and the application of firmly implanted tampons, the bleeding did not cease. At four o'clock in the afternoon of that day, the patient's pulse was 124, and there was increasing pallor. Under ethyl chloride anesthesia the thermocautery was applied. This was successful with the exception of an oozing from a very small point. The following day, the third in the hospital, the bleeding had been practically arrested, the patient had revived, and the pulse rate fell to 108. This condition lasted until the seventh day, but on the eighth day the bleeding increased again, when application of the thermocautery proved effective once more. At intervals, however, the bleeding alternately increased and decreased, the tampon being continuously employed and the patient enjoined to refrain from every unnecessary movement. Gelatin solution was repeatedly injected and local coagulin and suprarenin applied. Oil of turpentine was employed on the twelfth day. Notwithstanding employment of the above and all other available known remedies, the bleeding continued slowly but persistently; the patient was almost white, and the pulse rate rose to 116. After a few days the pulse increased to 138 and the patient's pallor became deathlike. On the seventeenth day vomiting began, with the pulse rate at 120; towards evening the pulse rate increased. The patient was semiconscious during the night of the seventeenth day to the eighteenth day, when death occurred after complete exsanguination and visible cerebral convulsions. Similar cases have been reported by Quinlan and others.

Recently, during a lecture before a dental society, a prominent exodontist made the statement that as the offending tooth must be removed, regardless of a patient's condition; he does not bother with tests, but proceeds with the operation. Such indifference cannot be condemned too strongly. This procedure may have been regarded as good practice some years ago, but cannot be justified in the light of the advancement of modern sur-

gery. To a great many practitioners a test of the blood, in so far as coagulation time and bleeding time are concerned, is a technic that requires test tubes, suction pumps, a well-equipped laboratory, etc. To dispel this delusion I shall present, in a concrete and concise manner, a means whereby every operator may, in his own office and in a very few minutes, verify or remove his own suspicion or the patient's belief. While the method is not perfect, at least it gives an index that will serve as a guide in determining whether or not premedication is necessary, and in conducting postoperative treatment.

It seems essential, in any discussion of the possible preliminary diagnosis and the prevention or control of hemorrhage, to summarize at the outset the essential factors in blood coagulation and the available methods for the determination of variations from the normal.

Coagulation, according to Howell's theory, is determined by five factors: (a) Prothrombin, activated by calcium salts (b) becomes thrombin, which acts on fibrinogen (c) to form fibrin. Prothrombin, which is held in combination with antithrombin (d) ordinarily while the blood is in circulation, coming in contact with thromboplastin—thrombokinase—(e), found largely in the tissue juices or being partially dependent on the number of disintegrated blood platelets, is allowed to act, due to neutralization of the antithrombin by the thromboplastin.

In clinical work, coagulation time with determinations of the character of the clot, bleeding time, prothrombin time, number of blood platelets, and calcium determination, can be made. As a possible index to detection of postoperative bleeding or hemorrhage, where dangerous capillary oozing is likely, the relative value of these procedures is roughly in this order:

(a), (b), (c) Coagulation time, bleeding time, and prothrombin time, are valuable. Relatively, prothrombin time and coagulation time tend to agree.

(d) Blood platelet count—valuable in so far as purpura may be diagnosed.

(e) Determination of blood calcium content is of questionable value.

Our study embodied determinations of coagulation time and bleeding time only.

Coagulation Time

For the determination of coagulation time there are several available methods of which the most accurate, tending to obviate some of the objectionable features in skin puncture methods (Howell, Lee and White, King and Murray, etc.), are those employing venipuncture. On the other hand, in the type of case upon which this study was made, the convenience of a skin-puncture method or some modification, such as the capillary tube, Biffi-Brook's, Boggs', Duke's, or Goeckel's procedure, makes it more desirable. It must be constantly kept in mind,

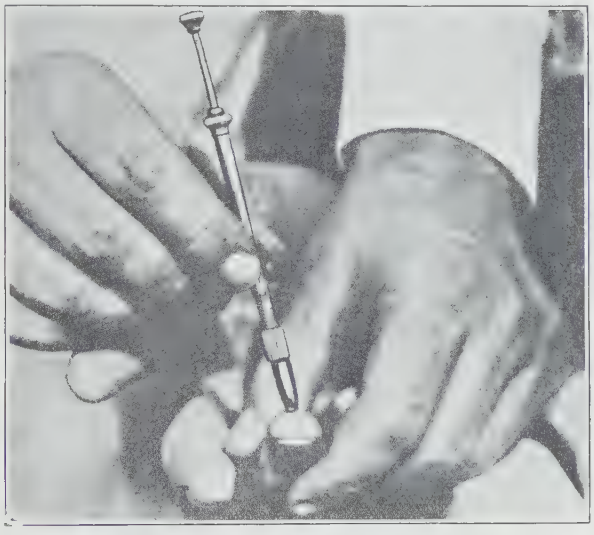


Fig. 39.—Lancet held in position, just before release of spring.

however, that with these methods there are certain dangers of serious error, which careful precaution alone can prevent.

Goeckel's method was used. The end of a finger is thoroughly cleansed with alcohol, and punctured with a blood lancet of the type that operates by the release of a spring, and the time of the appearance of blood is noted. A medium size drop of blood is immediately placed in the center of each of the two concavities in a hollow ground slide, which are slightly deeper than those used in microscopic agglutination tests, and a second similar slide is put over it. On tilting the slides gently, about every thirty seconds after the third minute, the noncoagulated blood

tends to gravitate toward the lighter area. As coagulation becomes complete, the drop solidifies and at times serum exudes from it. When coagulation is complete, the drop can be quickly exposed and the point of a needle touched to the coagulum,

Fig. 40.

Fig. 41.—Slide inverted, placing drop of blood in concavity. Fig. 40 shows another view of the process.

which then will show shreds of fibrin. Final reading is made at this time, which normally is about five minutes after withdrawal of the blood.

Attention should be drawn to the following facts relative to this method:

(a) In selecting a part of a finger for puncture, one should avoid areas where the epidermis has been unduly thickened.

(b) In order that the flow of blood may be comparatively free, the puncture should be deep (about 2-3 mm.), thereby avoiding pressure on the part and the introduction of thrombokinase or

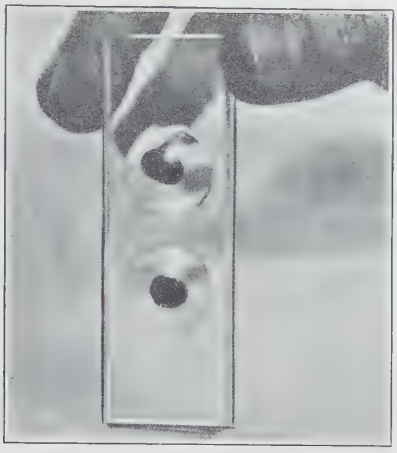


Fig. 42.—Slides together, giving relatively air-tight compartments; drops of blood are shown, with coagulation almost complete.

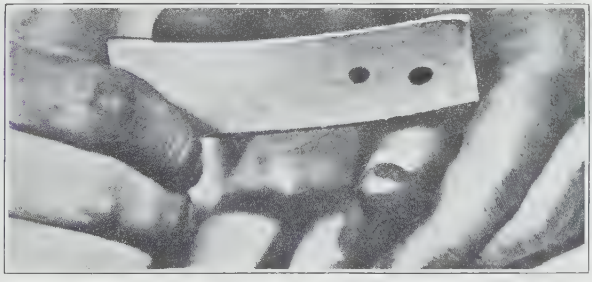


Fig. 43.—Filter paper, showing drops of blood; bleeding time is normal (first drops used in coagulation test).

thromboplastin from the tissue juices, which would tend to make the coagulation time artificially short.

(c) The slides should be at body temperature, thoroughly clean, free from grease, and dry.

(d) When one slide overlays the other slide, the concavities containing blood should be comparatively air-tight.

(e) The slides should not be allowed to slip on their surfaces of contact, otherwise the drop of blood would be smeared and the test vitiated.

(f) Unnecessary exposure of the blood to the air should be avoided.

(g) The method is simple, economical, and relatively accurate.

(h) Each sample of blood should be tested in duplicate.

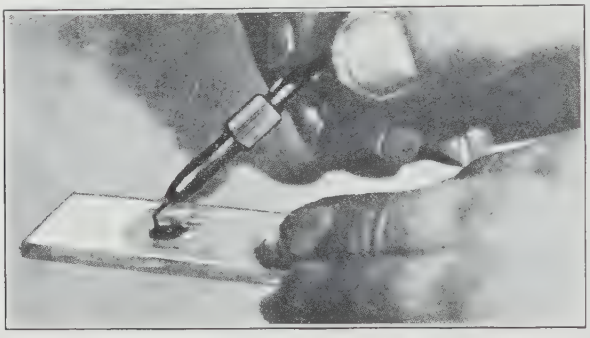


Fig. 44.—Coagulation complete, showing coagulum.

Bleeding Time

Bleeding time is the time required for a small cut to stop bleeding. Duke's method was employed. After thoroughly cleansing the part selected, commonly the tip of a finger or the lobe of an ear with alcohol, and making sure that the part is dry, puncture which should be slightly deeper than the one used for an ordinary blood count, is made with a lancet or scalpel, and the time is noted. At half-minute intervals, blot the wound with a piece of absorbent paper. Ordinarily bleeding ceases in from one to three minutes, but continuance for about eight minutes may be normal. While the conditions of the punctures should be as nearly uniform as possible (thickness of skin, form and depth of puncture), even deep punctures in normal individuals cease bleeding quickly. Further, in the blotting process, care should be taken to avoid dislodgement of the clot or squeezing of the punctured part, because the bleeding time would thus tend to be prolonged. One puncture suffices for determinations of both coagulation time and bleeding time.

Conclusions and Comment

A series of tests made at the New York University College of Dentistry, shows the average coagulation time to be four minutes and fifty-four seconds, and the bleeding time to be two minutes and thirty-five seconds. Normal figures have been recorded by various authorities as four to ten minutes and one to five minutes, respectively. A variation of a few minutes, however, is of practically no significance. When abnormal variations occur, ordinarily the tests can be easily checked; and if "times" are unusually prolonged, treatment is indicated. So far as we know, none of the patients on whom these coagulation and bleeding tests were made showed postoperative hemorrhage. Todd and others agree that tests of coagulation and bleeding times are indicated in all operations where oozing is liable to arise, as in jaundiced patients, and those who have had tonsillectomies. We venture to add that such tests should be routinely employed in oral work. The injection of suprarenin may play a part in the prevention of postoperative hemorrhage.

While true hemophilia is not common, is inherited, and is confined to males, cases of adventitious bleeding, due to other causes, occur occasionally. Therefore, while it may be necessary to make thousands of tests before one of these cases is found, it is well worth the effort if the consequences of unexpected hemorrhage can be forestalled or avoided.

In cases of prolonged coagulation time or bleeding time, the necessary premedication will depend upon their variation from the normal and the clinical diagnoses of the respective cases. Thus, it may be calcium chloride, 10 to 20 grains, three times a day, taken three days prior to operation; sodium citrate, etc. In keeping with the work of Partsch, if an operation on a "bleeder" cannot be avoided, it is advisable, twenty-four hours before the operation to inject 20 c.c. of horse serum or diphtheria antitoxin in the skin of the back. In hemorrhagic diatheses blood transfusions, x-ray treatment of the bone marrow, and, for severe cases, extirpation of the spleen, may be considered.

Hemorrhage is generally divided into three stages: primary, intermediate, and secondary. *Primary hemorrhage* is that

which occurs at the time of the operation. *Intermediate hemorrhage* is bleeding that recurs within twenty-four hours of the operation. *Secondary hemorrhage* is bleeding that takes place after a lapse of twenty-four hours. In several cases treated in the Oral Surgery Clinic, secondary hemorrhage has occurred five to seven days after operations.

The treatment of primary hemorrhage is not of serious importance. If it is at all persistent, pressure should be applied by means of sterile gauze, sponges, or pads. If the bleeding is from the alveolus, this should be packed with iodoform gauze (5 per cent). Frequent rinsing of the mouth does not diminish bleeding, but tends rather to stimulate it. Patients should not be dismissed until all bleeding has ceased, and before leaving the office they should be instructed in the emergency treatment to be instituted until medical aid arrives. It is a good procedure to provide the patient with some gauze sponges, which can be utilized, as directed, should an emergency arise while he is in transit.

Intermediate and secondary hemorrhages are more serious, and require heroic treatment. In our experience, in oral surgery these conditions always set in at night. When these cases are first seen, the patient is usually unable to talk because of the presence in the mouth of large masses of coagulated blood. Relatives or friends who may accompany the patient generally give a history of refusals of various dental surgeons to offer treatment, some patients even making the statement that entrance into offices was refused by attendants. The dental surgeon may fear, in such instances, that the patient is a hemophiliac and, not being responsible for the operation, does not desire to be involved in the consequences. The fact remains, however, that we are called upon to treat such cases, and, as they are the results of our own operations, we should be more competent to deal with them than the average medical practitioner into whose hands they frequently pass.

Four essential procedures should be followed in the treatment of intermediate or secondary hemorrhage: (a) wash, (b) localize, (c) cleanse, (d) compress. Equal parts of hydrogen peroxide and water, as hot as the patient can bear, should be used by means of a water syringe, and the mouth irrigated, thereby re-

moving all clots. By carrying out this technic the bleeding can be controlled for a sufficient length of time to localize it. If the bleeding is from the mucous membrane, search should be made

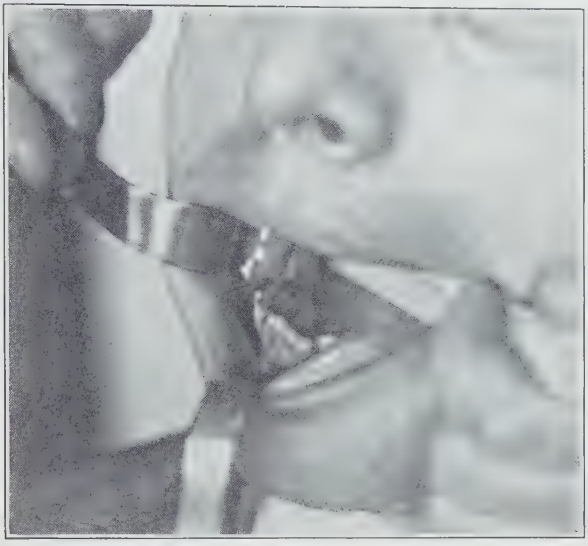


Fig. 45.—Control of bleeding. Compound placed between the teeth; patient closing the teeth slightly.

Fig. 46.—Saddle in position, with space on opposite side for nourishment.

for any small vessels that may be the cause, and if found they should be twisted or compressed. If a vessel is only partially divided, it should be completely severed, as this will probably allow contraction to take place. This method will be found

extremely useful in controlling secondary hemorrhage following the removal of growths in the upper jaw. If the bleeding is capillary in character, a pad of sponge or of sterile gauze applied with firm pressure is usually sufficient to stop it.

When the bleeding is from the alveolus, the following procedure is effective; an injection of novocaine-suprarenin is made in the strength of 1.5 per cent for the maxilla and 2 per cent for the mandible. The socket is thoroughly cleansed, with the aid of a curette. A strip of sterile gauze two inches long and an

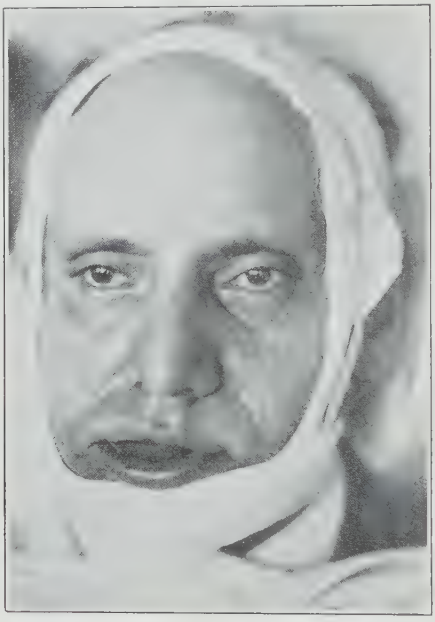


Fig. 47.—Barton bandage in position, to maintain pressure.

inch or one-half inch in width, saturated with suprarenin is inserted into the socket, and over this iodoform gauze is packed as firmly as possible. A pad of gauze is put over the socket, upon which there is placed a saddle of modelling compound, and a Barton bandage is applied to maintain the pressure. The saddle is prepared by taking a half sheet of modelling composition, softening it, and placing it in the patient's mouth on the side of the bleeding, after which procedure the patient is asked to close the mouth, not completely, just partially. It is then removed, chilled, and replaced. By having this saddle in position,

the desired pressure is maintained and a space is provided on the opposite side of the jaw, through which food may be taken. This dressing should be removed after twenty-four hours, and replaced if necessary.

In addition to packing the socket, hemostatics should be administered internally.

The general directions to be given to the patient, though apparently trivial, are most important, and should never be forgotten. He should be advised to go home very quietly, to avoid all forms of excitement, to assume the sitting position during the day, and to use a high pillow at night. The patient should be fed through a bent tube, and all fluids should be given cold.

CHAPTER XV

EXTRACTION OF THE TEETH

General Principles.—The operation of extraction of teeth is one which is sometimes attended with some degree of uncertainty and also difficulty. While the great majority of teeth come out without much difficulty, and are free from postoperative incidents, yet the experienced operator is sometimes confronted with cases that tax his abilities, either in the operation itself or in the sequelae that arise. The operation of extraction is one which requires skill, judgment, experience, and an accurate knowledge of the parts involved. As with all other manipulative procedures, desired results can only be obtained by actual practice.

Success in the operation of tooth extraction is dependent upon the following:

1. Asepsis.
2. Anesthesia.
3. The form or shape of the roots of the teeth.
4. The density and substance of the bone in which the teeth lie.
5. The position of the roots in the bone.
6. The selection of the proper instruments.
7. The operator's intuitive skill.
8. The prevention of accidents.
9. The treatment of accidents and sequelae.

The teeth which consist of crowns and roots, present an abundant variety of forms, shapes, sizes, and substance. The tooth to be extracted may give us some idea as to the means which we may adopt for its complete removal. The extraction must be carried out in the line of least resistance, for herein lies the greatest likelihood of the tooth coming out without fracture, either of itself or the bone in which it is situated. There is no possibility of classifying all the various movements necessary to the successful withdrawal of all roots, because of the variety of forms and conditions of many of them. The

movements which might be applied to a normal tooth might be quite inapplicable to the same tooth if in a broken-down state. Also many of them have a subtle twist in their general shape, especially the upper canines and the molars. Teeth with crowns which appear short, thick, and stout are usually long in the roots; long, bulbous crowns are often short in the roots; while crowns that are flat on their internal and external surfaces are long in the roots and well implanted in their sockets.

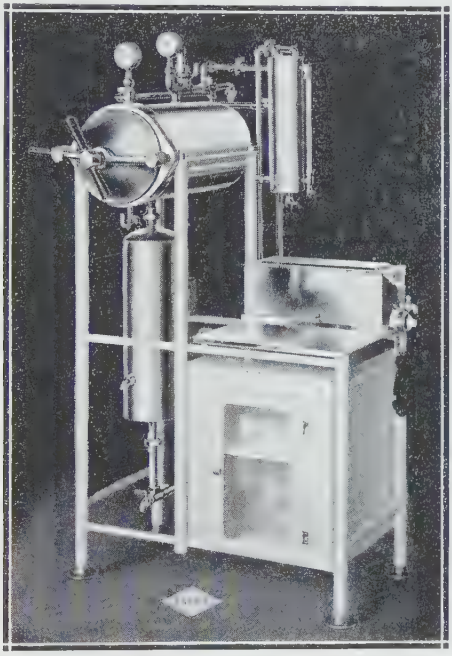


Fig. 48.—Type of sterilizer best suited for office of dental or oral surgeon. Having combination of wet and dry sterilization, distilled and sterile distilled water.

The density of the bone is another factor in successful extraction. In some cases the bone is soft and cancellous, so that the thin blade of a sharp instrument cuts its way quickly, and care is required to avoid damaging it and the vessels contained therein. In other cases the bone will quickly respond to the insertion of the forceps blade.

The important factor to bear in mind in the extraction of teeth is that we are not merely concerned with the removal of the particular tooth at all hazards, for the reason that such removal with its resultant danger would by no means justify the

operation. This difficulty may be readily overcome by the operator having at hand a sterile emergency tray which could be used for the removal of any broken fragment in case of fracture of the tooth.

The psychology of the patient must also be considered whenever the need for an operation confronts him. He is naturally nervous and fretsome. He fears the sight of the instruments and dreads their effect. In the presence, or in the anticipation

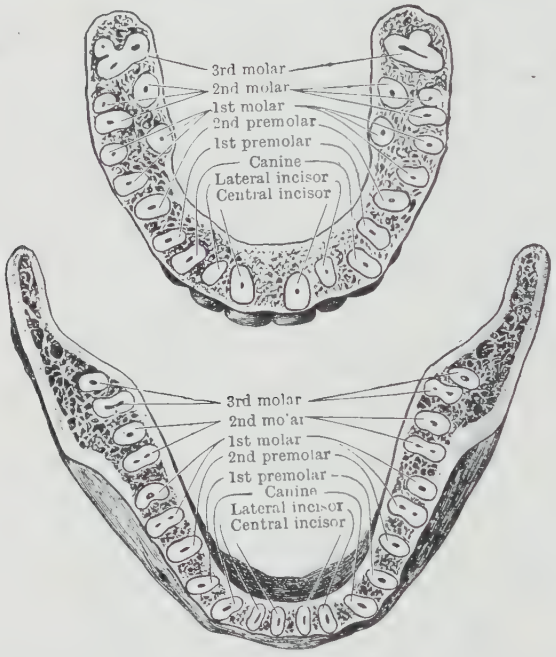


Fig. 49.—Horizontal sections through both the maxilla and the mandible to show the roots of the teeth. The sections were carried through the bones a short distance from the edge of their alveolar borders. The upper figure shows the upper teeth, the lower figure the lower teeth. Note the flattened roots of the lower incisors, the two root-canals in the anterior root of each lower molar, and the confluence of the three roots of the upper last molars. (From Cunningham.)

of such conditions premedication will prove serviceable. The practitioner has at his disposal a number of harmless sedatives tending to prevent or to eliminate these signs and symptoms. One 5-grain tablet of adalin administered internally an hour prior to the operation will prove effective in such cases, as will also a ¼-grain tablet of luminal. Another very useful product is camphorated validol, a liquid preparation with a pleasant, cooling taste which has proved efficacious in the indicated con-

ditions. From 8 to 10 drops are given fifteen to twenty minutes prior to the induction of local anesthesia. If for any reason the operation is to be deferred and pain is a factor, it becomes necessary to make the patient comfortable in the interim. Pyramidon medication, conveniently administered in the form of the 5-grain tablet to the adult—and this dose may be repeated if necessary for three to four hours—will accomplish this.

A very important consideration is the faith inspired by the operator in the patient. For example, a patient who is to have a tooth removed, the crown of which is broken down, will invariably ask, "Doctor, will this hurt?" After reassurance to the contrary, he will ask, "Will this tooth come out in one piece?" Here is where judgment on the part of the operator is essential. He advises the patient that the removal of the tooth in one piece is of minor consequence and that in order to induce as little trauma as possible he may decide to remove it in several pieces. If the patient has not been thus forewarned and after applying forceps, the tooth breaks, the patient becomes alarmed and nervous because of what he considers a catastrophe. If the operator has not sufficient confidence in himself, this lack of faith will rapidly impart itself to the patient. How much better it would serve, if, in attempting the extraction of the tooth an accident happens, the operator were to reassure his patient by saying, "It is exactly what was anticipated," and then proceed unconcernedly with the sterile instruments until the entire tooth and its roots have been removed.

The mere extraction of a tooth is not the completion of the task. After this step, all sharp portions of the alveolar process should be removed by means of Rongeur forceps or a thin beaked extracting forceps, to make sure that they do not subsequently act as irritants, preventing the proper healing of the wound, and also becoming a source of pain or inconvenience to the patient.

Extraction of Temporary Teeth

In removing temporary teeth, the possibility of permanent teeth resting directly beneath the temporary ones must constantly be borne in mind.

The question of the anesthesia to be employed is largely one of preference. Some method of anesthesia should be resorted to in order that children may not have a subsequent fear of future dental work. As a general rule, children under four years old should be given a general anesthetic. Beyond this age, local anesthesia may be resorted to if the child is of a tem-

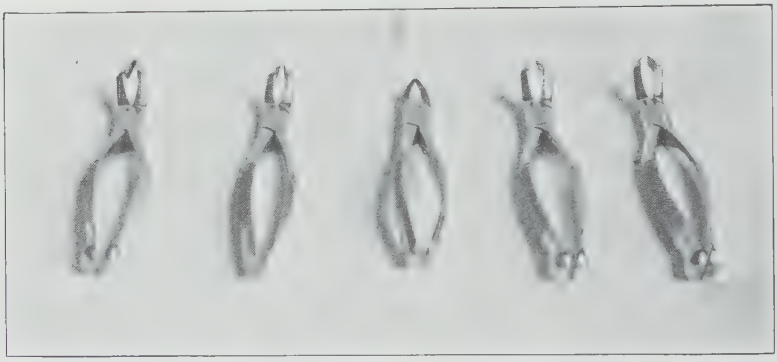


Fig. 50.—Illustrating forceps used in the removal of upper teeth. Thin beak forceps are used for anterior teeth; heavier forceps are used for the posterior teeth.

Fig. 51.—Illustrating forceps used for lower teeth.

perament to cooperate with the practitioner and will permit the injection of a local anesthetic.

In using novocaine, a 1 per cent solution is of sufficient strength, for the extraction of either upper or lower teeth. The forceps to be employed are the same as those for the extraction of permanent teeth. When the teeth are loose, the use of a very thin elevator will readily serve to lift them from their sockets.

Extraction of Permanent Teeth

The main instruments for extraction of teeth are forceps. However, they are not the only aids for this purpose as there are accessory instruments, such as elevators which, in their particular place, are highly advantageous.

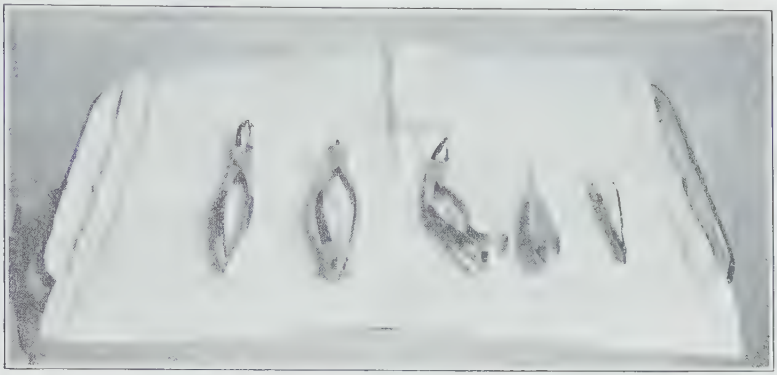


Fig. 52.—Tray of instruments for extraction of upper or lower teeth.

Fig. 53.—Emergency tray. A sterile tray containing the following instruments should be at hand, to be used in an emergency, in case of fracture of a tooth: knife, thumb forceps, periosteal elevator, mastoid gouges, curettes, elevators, scissors, mallet, cheek retractor, suturing needles, horse-hair needle holder, gauze swabs.

The attitude of the operator should be easy and unconstrained, so that his strength may be exerted to the best advantage. With this in view, the operator's hand should be held fairly close to the side, so that its movements may be well regulated and under control. The head of the patient is raised or lowered, the chin thrown upwards or depressed as the needs require and the head always so turned towards the operator that

Fig. 54.—Position of forceps for removal of lower anterior teeth. Operator should stand behind and to the right of patient, the left arm supporting patient's head. Thumb of the left hand to protect the tongue, index finger to retract the lip, and the remaining fingers to support the jaw. Beaks of the forceps to be placed parallel to the long diameter of the root and in the case of single rooted teeth a rotary or slight twist employed, or if this method does not luxate the tooth, then the pressure exerted outward should be used.

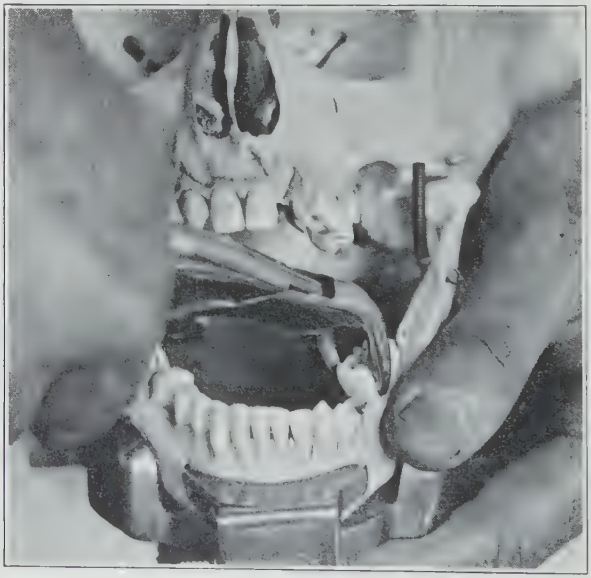


Fig. 55.—Position of the operator, patient and the forceps for the extraction of posterior teeth, lower jaw, left side. The thumb of the left hand is used for the retraction of soft structures, the fingers support the jaw. Beaks of the forceps are placed parallel with the long diameter of the roots. Force is exerted outwardly.

Fig. 56.—Technic for removal of lower teeth by means of the Cyer Universal forceps. In using these forceps the operator stands in front of the patient, the thumb and the index finger of the left hand are used to retract the soft structures and the remaining fingers to support the jaw. The force applied for the anterior teeth is of the rotary nature, having first applied a slight buccal and lingual force. For the posterior teeth, force outwardly is indicated.

Fig. 57.—Position for the removal of lower bicuspids and molars, right side. The operator should take his position to the right and behind the patient. The jaw should be supported with the fingers of the left hand, the index finger being used to retract the soft tissues, the thumb to protect the tongue, and the remaining fingers to support the jaw. The beaks of the forceps are placed in position under the mucous membrane, buccally and lingually parallel with the long diameter of the roots.

his fingers may have easy access to the particular tooth to be operated upon. If the tooth to be extracted be in the upper jaw, his left hand should be used to steady the jaw during the application of the forceps, and to aid the extraction by providing an opposing force to the traction of the instrument. To

Fig. 58.—Illustrating the use of a cross cut fissure bur for the purpose of separating the mesial from the distal root in cases where the crown portion has been completely destroyed and is slightly beneath the gingival margin.

effect this he should grasp firmly, with finger and thumb, the alveolar process on both sides of the tooth he is about to remove. If the tooth to be extracted is in the lower jaw, the left hand should be used to prevent all rocking and depression of the mandible by rigidly securing it between fingers and thumb.

In using the forceps, the tooth should be grasped very lightly

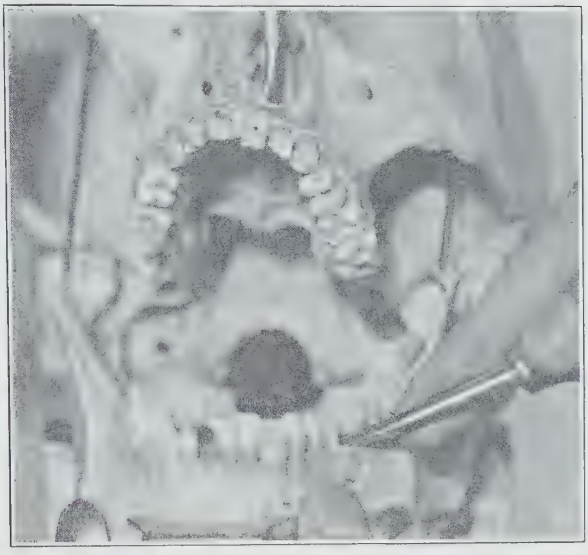


Fig. 59.—Illustrating the placing of the east and west or right and left elevators into the socket of the root which has been removed, breaking the intervening septum and lifting up the remaining root.

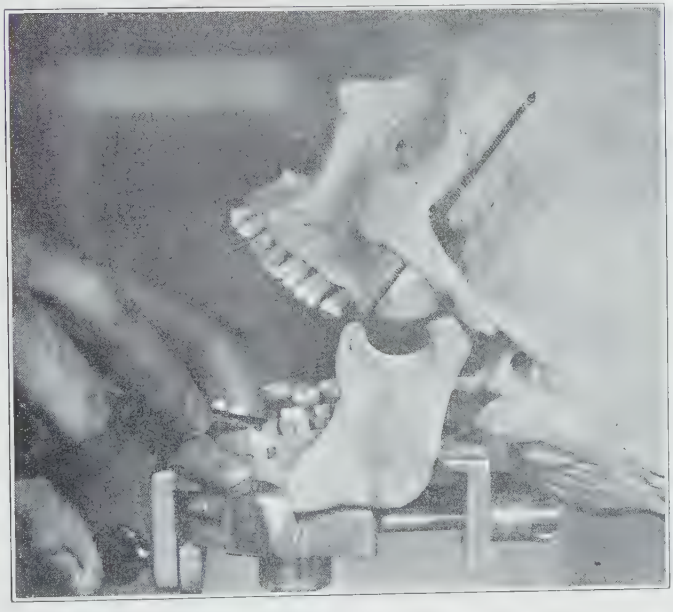


Fig. 60.—Illustrating the position of the right and left elevators for the purpose of releasing the roots after their separation.

Fig. 61.—Position of forceps for removal of upper anterior teeth. The beaks of the forceps should be forced under the mucous membrane, buccally and palatally, never over the mucous membrane. The beaks should always be placed in a parallel position to the long diameter of the root. The beaks are then closed firmly and a slight rotary motion will succeed in luxating the tooth. The fingers of the left hand should be used for the retraction of the soft structures.

Fig. 62.—Removal of upper anterior roots. A gouge elevator may be employed for the removal of broken upper anterior roots. The elevator is forced between the lingual plate and the root, thus wedging the root out of the socket.

between the blades in order to allow them to travel readily alongside its root, and to accomplish this, the thumb should be pressed between the handles, close to the joint. Thus, the operator may inform himself as to the amount of force with which he is gripping the tooth. The beaks of the forceps should always be well below the margin of the socket. Upper forceps should be so held that the ends of their handles rest against the

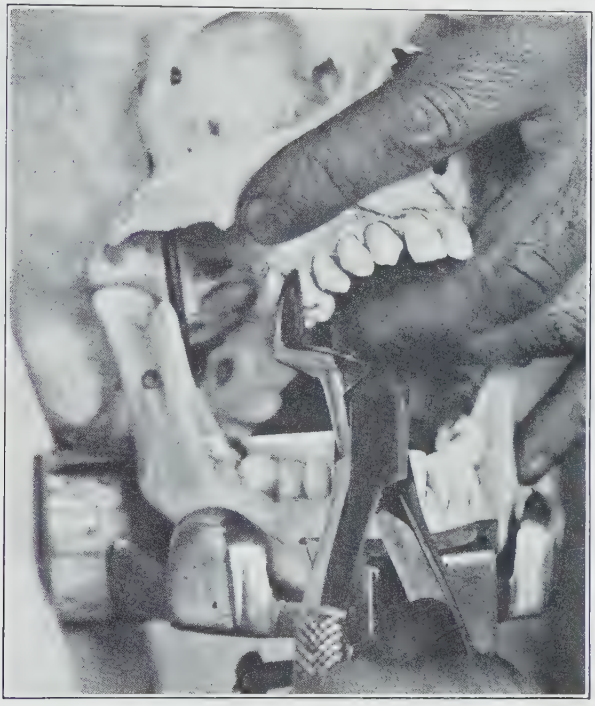


Fig. 63.—Extraction of molars of the right side, upper jaw. Patient's head should be tilted back slightly. Beaks of the forceps should be placed under the mucous membrane, a slight distance upward, palatally and buccally, parallel with the long diameter of the roots. The fingers of the left hand are used for the retraction of the soft structures. Care should be taken to avoid injuring the lower lip with the handles of the forceps.

palm of the hands. The long axis of the blades of the forceps should be continued in the same direction as the long axis of the tooth. If this be disregarded the hinges of the forceps may impinge upon the neighboring tooth, which by its resistance may not only greatly hamper the operator during extraction but may also be the cause of fracture of a tooth—a not infrequent accident.

The eye of the operator should be *fixed upon the tooth,* never to be lost sight of throughout the operation. The tooth in question should never be obscured by blood, by the patient's tongue, by the operator's hand, or by the forceps. It should be firmly grasped by the forceps, care being taken that the latter do not slip around the tooth while the effort to extract is being made.

In extracting incisors, canines, and bicuspids with single roots, force in the nature of rotation should be resorted to, to-

Fig. 64.—Extraction of molars of left side, upper jaw. Patient's head should be tilted back slightly. Beaks of the forceps should be placed under the mucous membrane a slight distance upward, palatally and buccally, parallel with the long diameter of the roots, and force should be exerted in an outward direction. The left arm is used to support the patient's head and the fingers of the left hand for the retraction of the soft tissues.

gether with a little rocking if necessary. The tooth should be grasped with the forceps and rotated on its long axis for about $\frac{1}{32}$ of a circle, when it will become loosened from its surroundings. This movement produces a separation of the root from its membranous connections and also tends to enlarge its socket. In removing multirooted teeth, such as upper first bicuspids and molars in either the upper or the lower jaw, a rocking motion

should be resorted to. By this is meant a movement inward and outward of the crown, thus endeavoring to break down the wall of least resistance, which in the majority of cases is the outer plate, although at times it is the inner plate. The operation of extraction should not be considered complete until, following the complete removal of the tooth, all loose portions of alveolar process are removed, and all sharp edges made smooth to avoid pain and irritation to the patient.

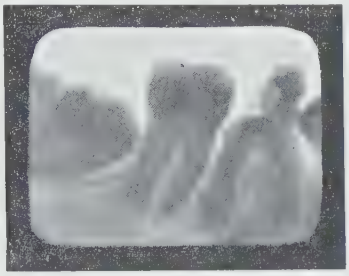


Fig. 65.—Hypercementosis of roots of first molar, indicating need for separation of roots and removal individually or resort to technic of surgical removal.

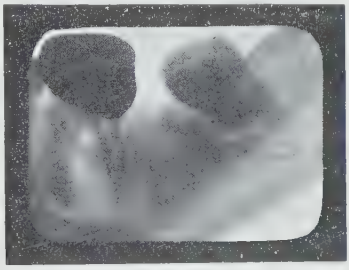


Fig. 66.—Surgical removal of first molar indicated because of bone rarefaction and presence of distal root of second molar.

Accidents in Extraction

Breaking of Tooth.—This may be caused by lack of proper technic in the application of the forceps, or to the long-continued process of decay which has softened the structure of the roots. This condition favors collapse of the walls of the roots as soon as pressure is brought to bear down upon it.

Roots may be considerably curved and have a thick septum of bone between them. They may be exostosed.

Dentine, as a result of certain systemic changes, may become brittle as glass.

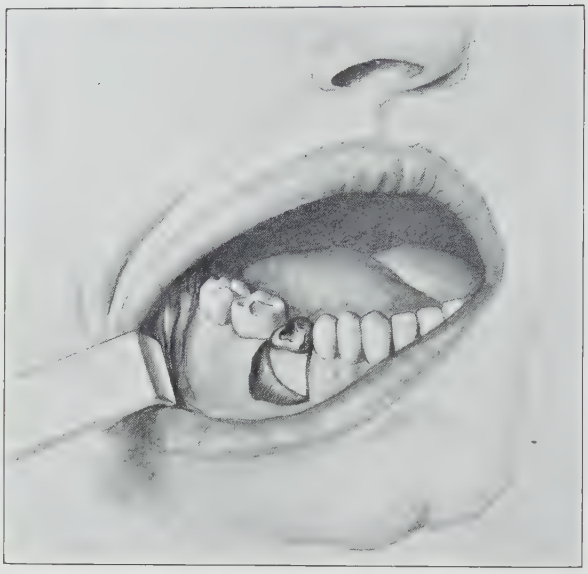


Fig. 67.—Surgical removal of mandibular teeth. Nature of the incision and elevation of the mucoperiosteal flap.

Fig. 68.—Surgical removal of mandibular teeth, showing removal of external plate by the aid of a mastoid gouge and mallet force. The gouge should be held almost at right angles to the mandible.

The outer border of bone, instead of being of the honeycomb, spongy variety (alveolar process), may be of the hard, solid, ivory-like consistency or may simply be unusually thick.

From any of the above causes, a tooth or root may be broken, and blame in many cases is not to be attributed to the operator if such an accident occurs. If the root is broken off below the gum margin, no further attempt by aid of forceps should be made. If it be a multirooted tooth, the roots may be separated by the aid of a fissure bur and then removed individually; or

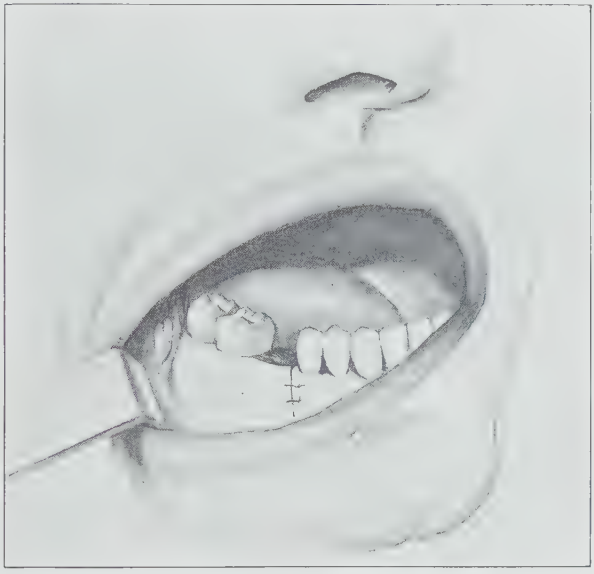


Fig. 69.—Surgical removal of mandibular teeth showing flap brought back and sutured.

attempt may be made to remove them by the aid of elevators of different varieties. Should these methods fail, in order to avoid the laceration of the soft structures, an incision should be made; the soft structures retracted, the overlying bone removed for a sufficient distance to expose two-thirds of the root portion, whereupon the root may be readily removed by the aid of an elevator. Sharp edges of bone should then be made smooth, the wound irrigated with a mild antiseptic solution and the flap brought back into position and sutured with horsehair. Horsehair is most advantageous in suturing membranes since its thin-

ness admits of the use of a small needle, thus lessening the danger of tearing the lips of the wound.

This so-called surgical removal of teeth should be employed also in cases where there is an area above or below the roots of

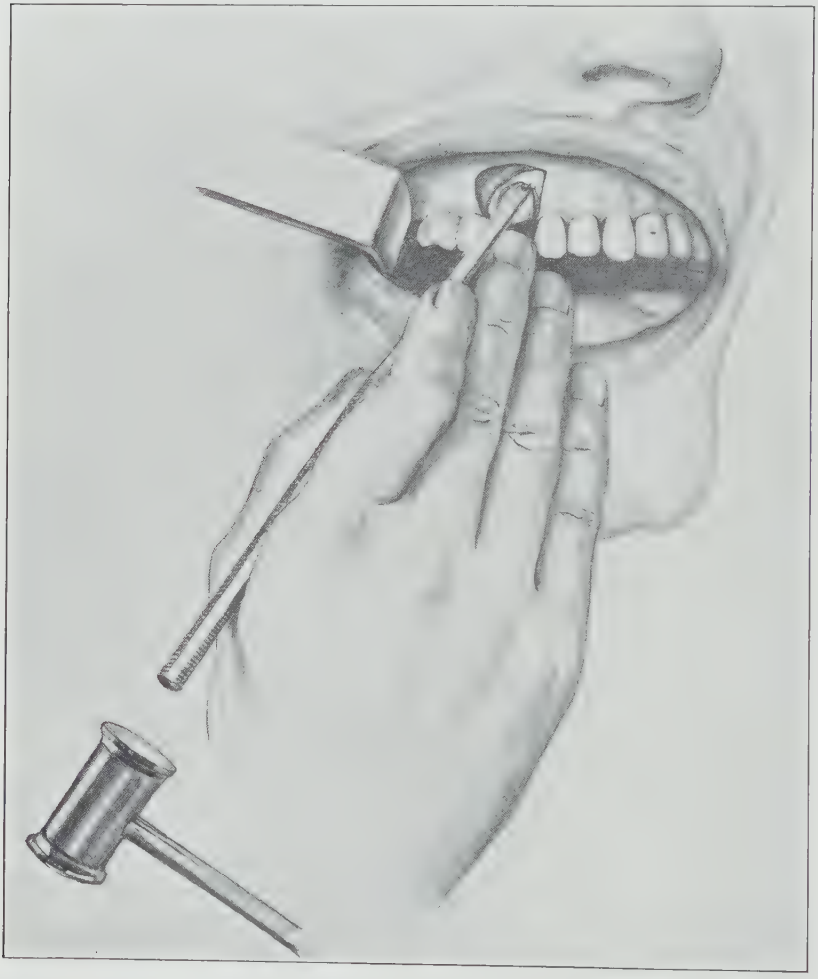


Fig. 70.—Surgical removal of maxillary teeth. Technic showing nature of incision, retraction of the mucoperiosteal flap, and removal of overlying buccal plate for a distance of two-thirds upward on the root by the aid of a mastoid gouge and mallet force.

these teeth, the nature of which it would be reasonably supposed could not be effectively reached through the socket.

While removing the lower molar, an upper incisor may be broken by the back of the forceps. This results from the sudden

parting of the tooth from its socket after a prolonged effort has somewhat exhausted the muscular power of the operator. The operator may guard against this accident by keeping the operating arm well under control, and by intently watching for the moment when the tooth is about to be severed from its connection with its socket.

The alveolar process may be fractured and indeed it is very common to find a small fragment of the outer alveolar plate adherent to the roots of the molar after it has been removed.

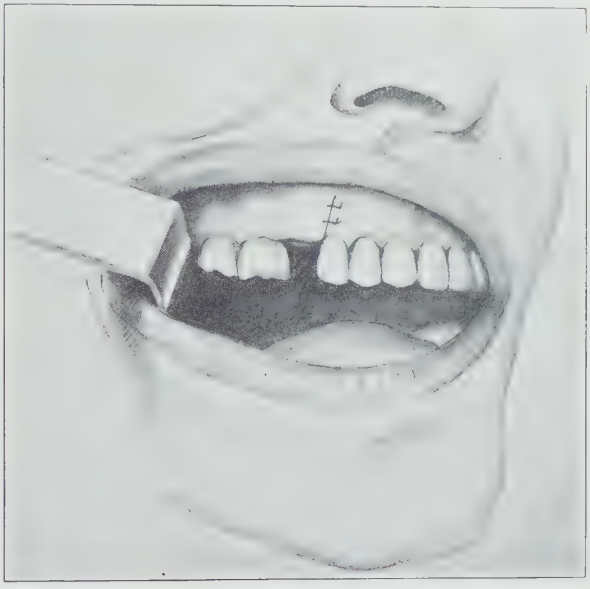


Fig. 71.—Illustrating the flap brought back and sutured, following surgical removal of a maxillary tooth.

When this accident occurs, the portion from which this fragment has become separated should be made smooth in order to prevent further irritation. Care must be exerted in the removal of upper molars to prevent breaking off of the tuberosity of the maxillary bone.

The mucous membrane through its occasional strong adhesion to the neck of the tooth may be lacerated during the removal of a tooth. If this condition be present a knife should be used to divide it before the tooth is removed from the socket and subsequently the membrane should be sutured into position.

The extracted tooth or root may slip from the grasp of the instrument and passing into the trachea may cause much trouble. This is an accident which those operating upon an anesthetized patient should guard against by having a throat pack in position.

Fig. 72.

Figs. 72-75.—Osteomyelitis of the mandible extending from molar to molar, following the extraction of a tooth. Treatment for these cases should be conservative, immediate incision and drainage.

A tooth, other than the one designed to be extracted, may often be removed in error. This accident can result only from want of care and should be guarded against by closely watching the tooth which the forceps are enclosing. During hurried extractions under nitrous oxide this unfortunate accident is most

liable to occur, when the instrument is applied within the mouth after the removal of the face inhaler, by an operator whose haste and nervousness may prevent him from recognizing the particular tooth with which he is dealing.

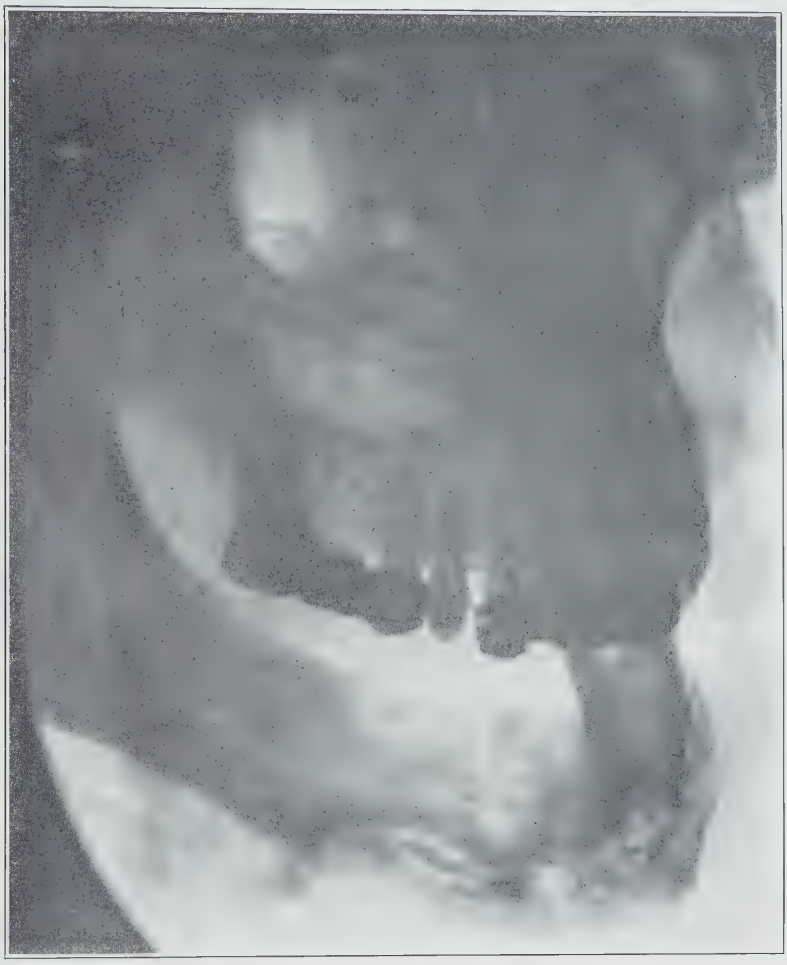


Fig. 73.

The root or roots of a bicuspid or molar may be forced to the antrum of Highmore or into the maxillary sinus. This accident may occur if the operator has not opened the blades of his forceps sufficiently while placing them directly against the surface of the root. It may also occur where the slightest pressure with

an elevator is used against the root in cases where an infection of long-standing has caused a direct continuity, or has caused the destruction of the bone from the root into the sinus. When this accident occurs, the opening into the antrum should be enlarged by the aid of a large round surgical bur, and the opening irri-

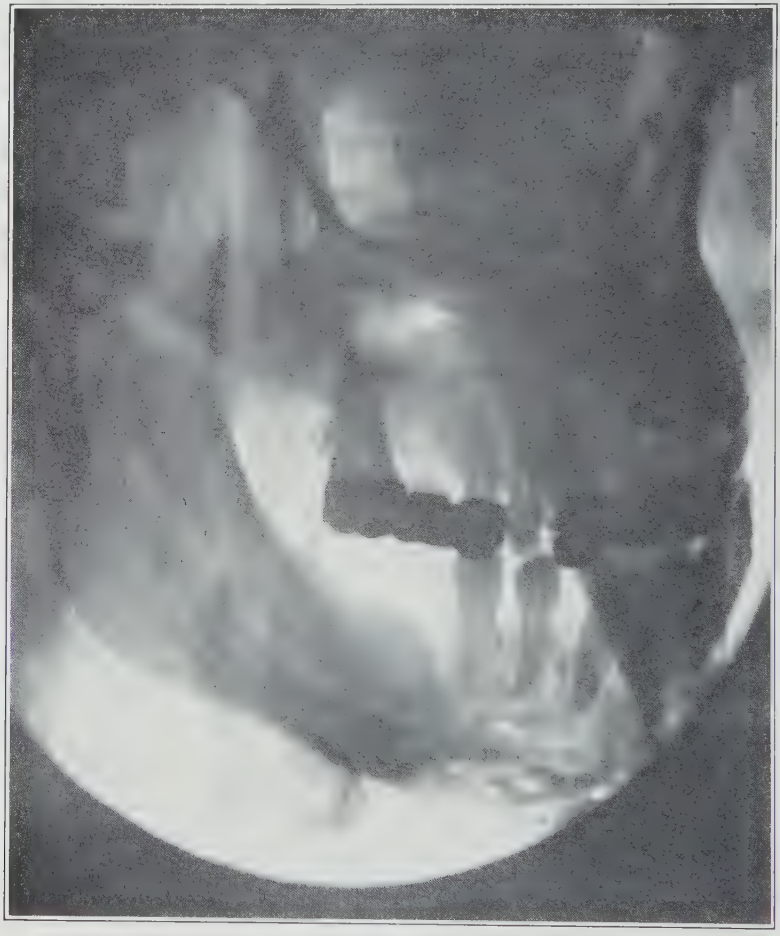


Fig. 74.

gated with a warm normal saline solution, when oftentimes the root will be flushed out through the opening. When the root is not eliminated by this procedure, an incision should be made and the soft structures retracted, the overlying bone removed and by the aid of curettes, the area cleaned out and the root

removed. At times, after the overlying bone is removed, exposing a portion of the antrum of Highmore, the root may be seen and in that case should be grasped by a pair of long, thin forceps.

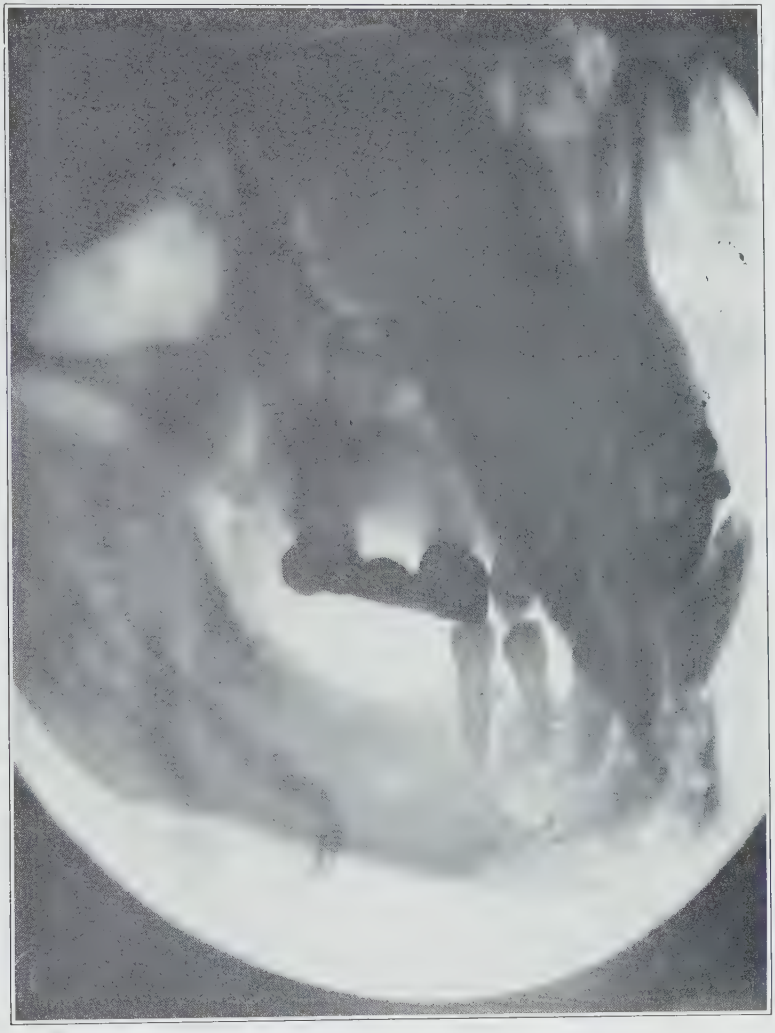


Fig. 75.

In the removal of roots that are broken off below the gum margin, very often it will be found that by the use of either a round bur or fissure bur or spear-pointed drill, the surrounding

bone of the root may be relieved and the root or apex removed advantageously.

This procedure is particularly applicable in the removal of apices of bicuspids or incisors where it is desired to avoid injuring the overlying bone.

Fig. 76.—Osteomyelitis following removal of mandibular bicuspid. When complete sequestration has taken place, as in this case, the sinus should be enlarged and the sequestrum removed.

Extraction of Teeth When Edema Is Present

There seems to be an erroneous impression existing on the part of the laity, as well as some dental surgeons, that to remove a tooth when the face is swollen is a wrong procedure. There is

no basis for this opinion and it should be discouraged. The only danger in the removal of teeth when the face is swollen is through the injection into an infected field, and in that manner force some of the purulent material into the healthy adjacent tissue beyond. This can readily be avoided through the use of

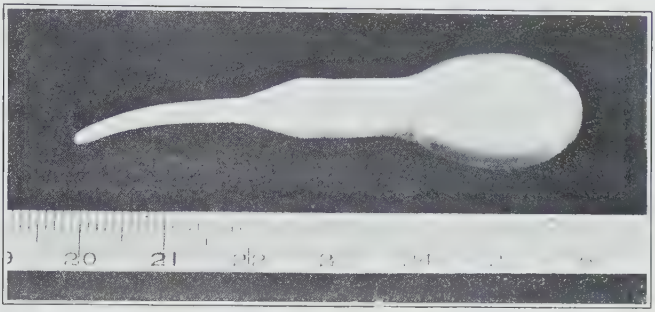


Fig. 77.—Photograph of Pariphor collapsule, for use in postoperative pain.

Fig. 78.—Showing method of using "Pariphor collapsule," for controlling postoperative pain. The collapsules contain a sufficient quantity for use in two or three sockets. They are so constructed as to be used in either the maxilla or mandible. The tip of the collapsule is cut off and the contents squeezed into the socket. Care must be exercised not to use the collapsule in wounds where pus is present.

conduction anesthesia either by way of the intra-oral or the extra-oral route, or by the use of a general anesthetic. The question of creating a fresh wound, such as would follow the extraction of a tooth and the subsequent infection of the wound by reason of the purulent material present, does not hold good in so far as the buccal cavity is concerned.

CHAPTER XVI

DISLOCATION OF THE JAW

Dislocation of the jaw, either bilateral or unilateral, may occur from the sudden spasmodic action of the muscles when the mouth is opened too widely. The treatment for this particular condition is the simple one of wrapping gauze around each

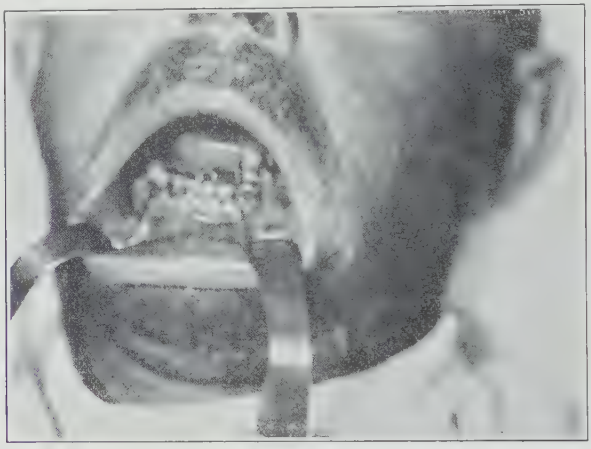


Fig. 79.—Compound fracture of the mandible between the first and second bicuspids. Note deformity.

thumb and of pressing downward and backward upon the occlusal surfaces of the last molars in the mandible; thereupon the disjointed condyle will slip back into place, promptly.

Fractures of the Jaw

Fractures of the jaw may occur if undue force is used in the attempt to remove a tooth. The utmost care should be exerted in the treatment, which comprises coaptation (bringing the parts together) or immobilization or fixation (keeping them stationery), until union has taken place. The methods employed depend in a great measure upon the location of the fracture, whether it be the anterior or posterior portion of the mouth; secondly, upon the amount of deformity induced. If the frac-

ture occurs in the mandible during the removal of a tooth in the anterior portion of the mouth and there are teeth present on either side of the fracture, a single arch splint may be success-

Fig. 80.—Illustrating use of author's fracture appliance in case of compound fracture of the mandible, first and second bicuspid region.

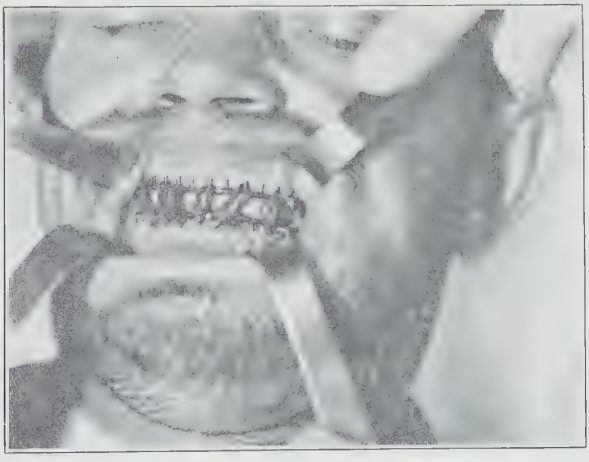


Fig. 81.—Compound fracture of the mandible with deformity reduced; appliances in position.

fully employed. Should the fracture occur in the posterior portion of the mouth, or where there is considerable deformity induced, an interdental appliance must be used, the upper jaw being used as a splint to which the lower jaw is attached, and the deformity reduced in this manner.

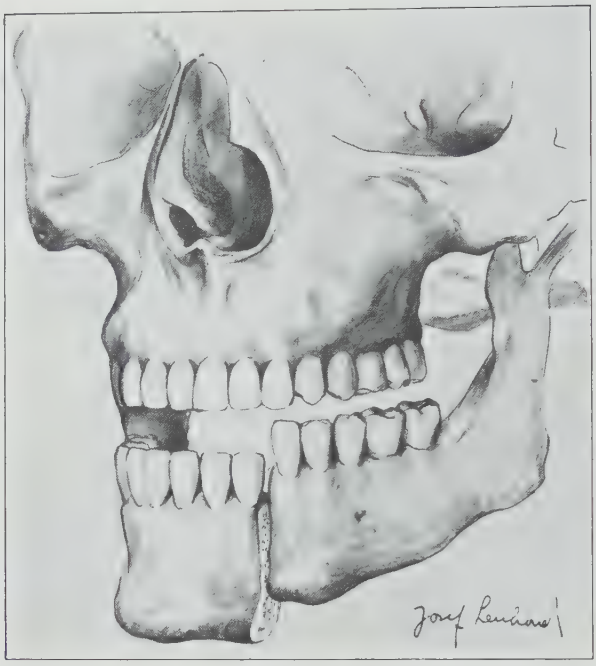


Fig. 82.—Fracture of the mandible in the region of the canine, showing characteristic malocclusion.

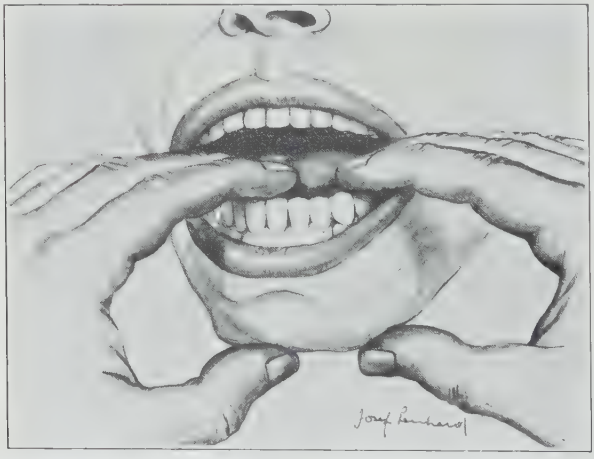


Fig. 83.—First step in the treatment of a fracture of the mandible is to coaptate or bring together the broken parts. In so doing, care must be taken not only to bring the parts together but also to restore the articulation which existed prior to the fracture. The best means to bring this about is to place the fingers of each hand on the incisal or occlusal surfaces of the teeth and the thumb of each hand under the mandible.

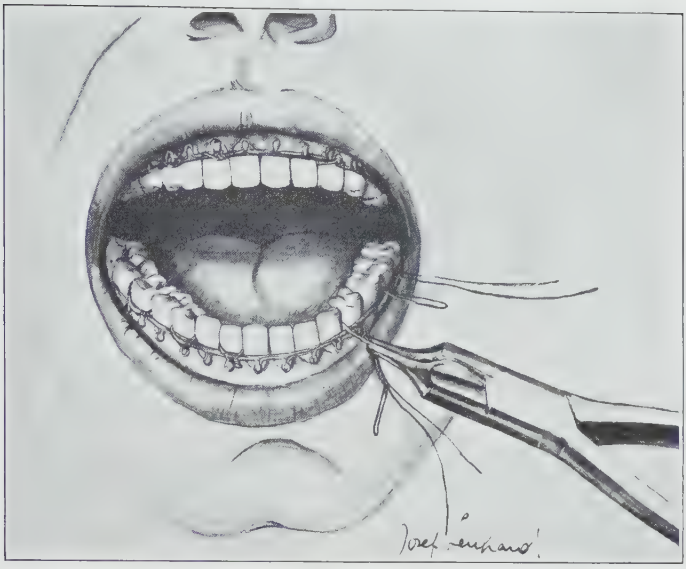


Fig. 84.—The second step in the treatment of the fracture of the mandible is to keep the broken parts together (immobilization or fixation) until union takes place, which generally occurs in twenty-eight to thirty-two days following the injury. Regardless of the type of fracture existing, an appliance is necessary. The appliance illustrated is applicable in fractures of the mandible or maxilla, providing some teeth are present. The technic consists in attaching the metal arch to the dental arch by aid of brass ligature wires. In fractures of the mandible occurring in the anterior portion of the mouth, with little deformity, and teeth on either side of the fracture, a single arch appliance will suffice.

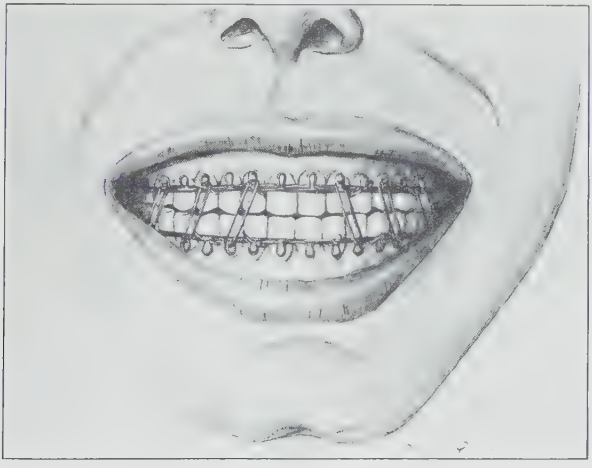


Fig. 85.—Treatment of fractures of the mandible in the posterior portion of the mouth or anteriorly with considerable deformity, require an interdental appliance. The author's splints, as illustrated, obviate the necessity of intermaxillary wiring by the use of elastics attached to the lugs on the metal arches.

My fracture appliance serves as an excellent means either for single arch appliance or for interdental appliance in the treatment of fractures. These appliances, which have been slightly modified and improved, should be kept in position for from twenty-four to twenty-eight days and then removed.

The principal points to have in mind are that teeth should not be extracted with forceps, according to numbers, as outlined by dental manufacturers, but rather to use thin beaked forceps for anterior teeth, heavier beaked forceps for posterior teeth, keeping the beaks of the forceps parallel with the long axis of the tooth; and where difficulty arises in the removal of these teeth by forceps to resort to the use of accessory instruments.

CHAPTER XVII

IMPACTED SUPERNUMERARY TEETH

Impacted supernumerary teeth, while occurring at times in adults, present themselves most frequently in children. Extreme care must be exercised in their removal for it may be readily understood that failure to recognize the presence of the invisible permanent teeth may result in their injury.

In children the removal of the supernumerary teeth offers little difficulty. Most often their position in the arch is revealed by digital palpation. When this method fails, proper radiograms will furnish the guide.

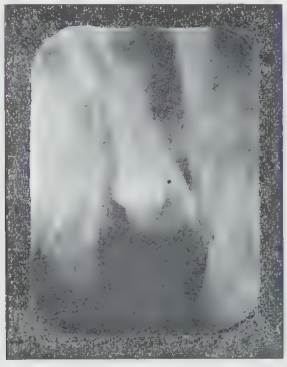
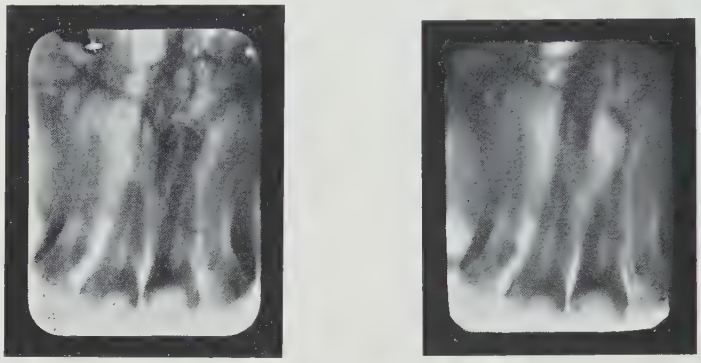


Fig. 86.—Impacted central incisor and impacted supernumerary tooth situated palatally.

When situated on the buccal surface of the arch, an incision, mesially and distally and including the incisal edge, followed by the retraction of the overlying soft structures will offer an excellent view. Overlying bone, if any be present, is removed and the supernumerary tooth or teeth removed. The wound should then be irrigated and the flap brought back into position and sutured.

When through radiographic findings or digital palpation such teeth are found palatally, the following should be the procedure:

An incision is made on the palate, beginning at a point approximating the lateral incisor, and is carried down on the palate to a point approximating the bicuspid. Then by the aid of a broad periosteal elevator the soft structures are separated



A *B*

Figs. 87-*A* and *B*.—Impacted supernumerary tooth before and after removal.

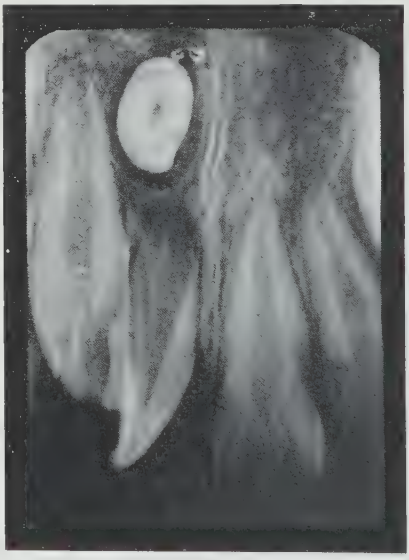


Fig. 88.—Impacted supernumerary tooth situated palatally, showing absorption of root of central incisor.

(including the gingival margins of those teeth which are in position) and the overlying bone is removed; the teeth are thus exposed, and are thereupon extracted. The rough edges of the bone should be made smooth, the wound irrigated, and sutured

with horsehair. The sutures should be permitted to remain for at least six days; cutting them directly in the center readily admits of their removal. These wounds require no dressings. The only precaution necessary is to advise the parent or guard-

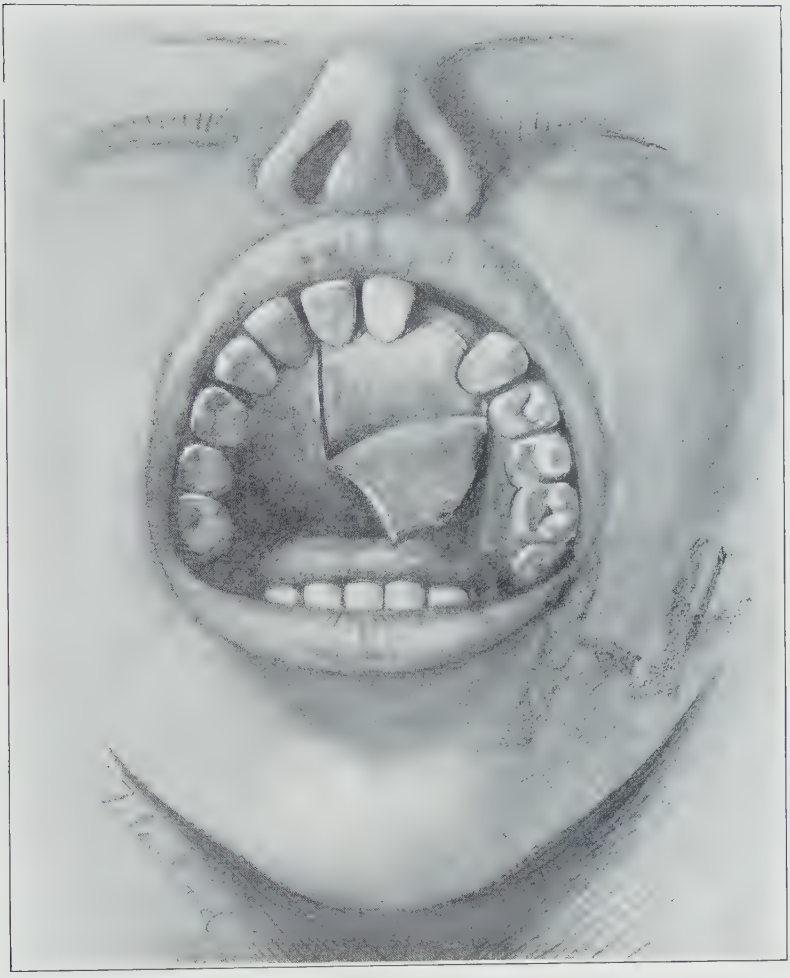


Fig. 89.—Nature of incision for impacted supernumerary or lateral incisor situated palatally.

ian how to apply pressure by the aid of sterile gauze tonsil sponges in case of profuse bleeding.

Supernumerary teeth when present in adults are discovered only through radiographic findings. The position of the teeth

in the arch cannot be determined by digital palpation. Careful radiograms must be taken to act as a guide in determining the position of the teeth in the arch. In practically all cases they are found to lie palatally slightly higher or on the same plane as the apex of the teeth in the arch. Supernumerary teeth in adults occupy such a high position in the arch as to render their removal at times extremely difficult. Possible injury to the apices of the central or lateral incisors must be explained to the patient prior to the operation in order to be relieved of any possible blame subsequently.

The technic for the removal of impacted supernumerary teeth is analogous to that employed for the removal of impacted maxillary canines, classification No. 1, illustrated in a subsequent chapter.

CHAPTER XVIII

IMPACTED MAXILLARY INCISORS

When upon digital palpation the presence of an impacted tooth cannot be determined, then careful radiography should be resorted to, and the operation performed according to the location of the crown in the radiogram. The crown, being the portion of largest diameter, must necessarily be freed from overlying bone in order to remove the tooth without causing irreparable injury. When the tooth is discernible on the labial or buccal aspect, it should be removed buccally. When the crown portion appears palatally, the tooth should be removed

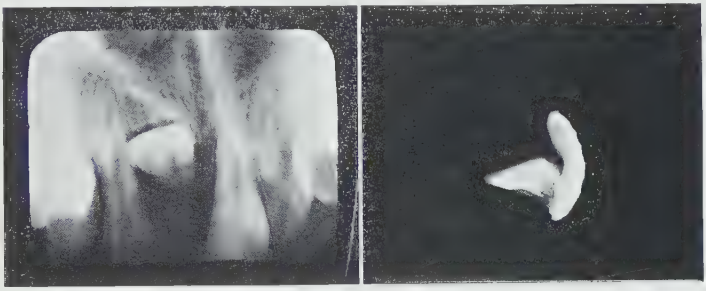


Fig. 90.—Impacted maxillary central incisor. This type of impaction may be removed either by way of buccal or palatal route; decision depending upon the evidence of the presence of the tooth or bulging of the bone upon digital palpation.

from the lingual aspect. The technic necessitates an incision on the palate distally to the lateral incisor and extending down on the palate to a point approximating the first bicuspid, and separating the soft tissues from the bone including the gingival margins of the teeth in position. The overlying bone is removed, and the tooth extracted. The flap is then brought back into position and sutured. When it is found that the tooth is situated buccally, a vertical incision mesially to the tooth is made, the gingival margin of the impacted tooth being included, the soft structures are retracted, the overlying bone is removed and the tooth extracted. The usual postoperative procedure should be carried out.

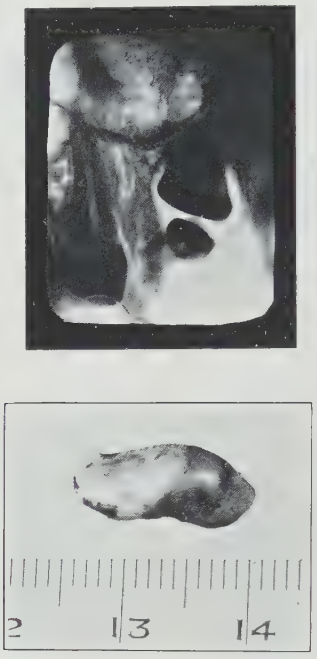


Fig. 91.—Impacted maxillary central and supernumerary tooth involved in dentigerous cyst.

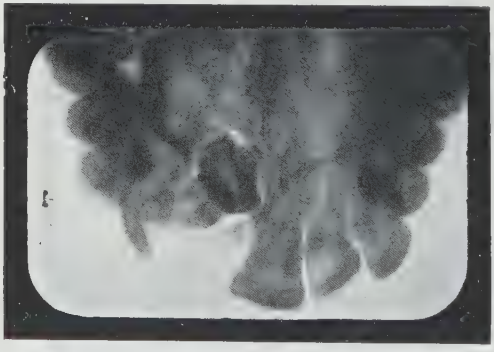


Fig. 92.—Impacted maxillary central incisor, with crown directed lingually.

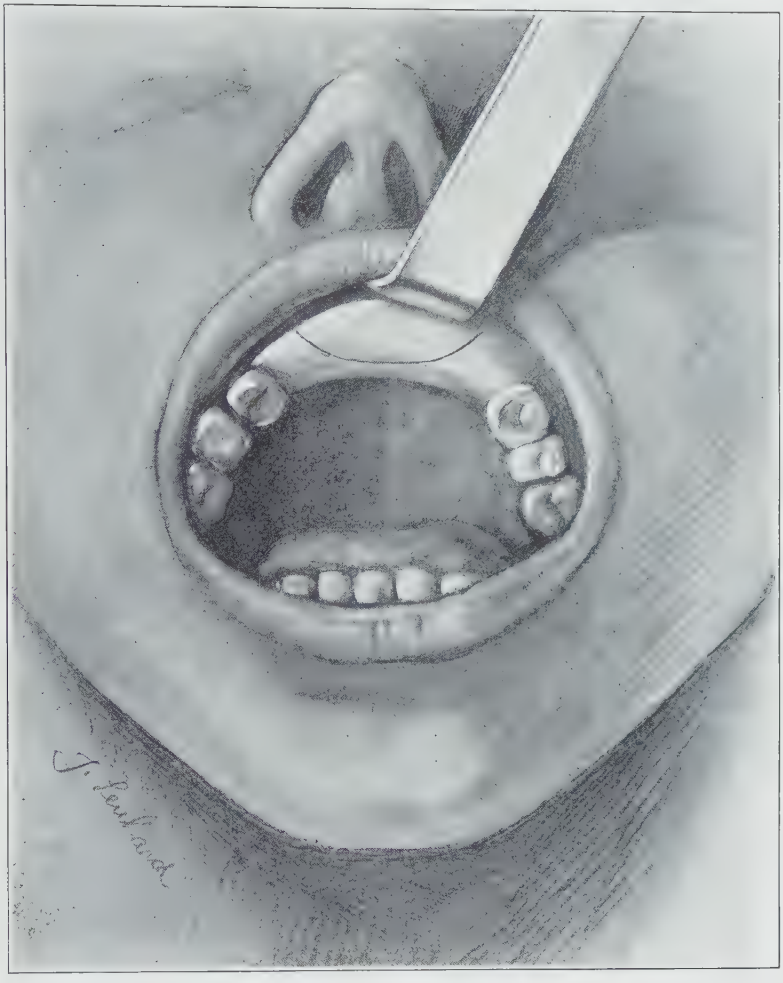


Fig. 93.—Nature of the incision for the exposure or removal of impacted anterior teeth situated buccally. (Edentulous area.)

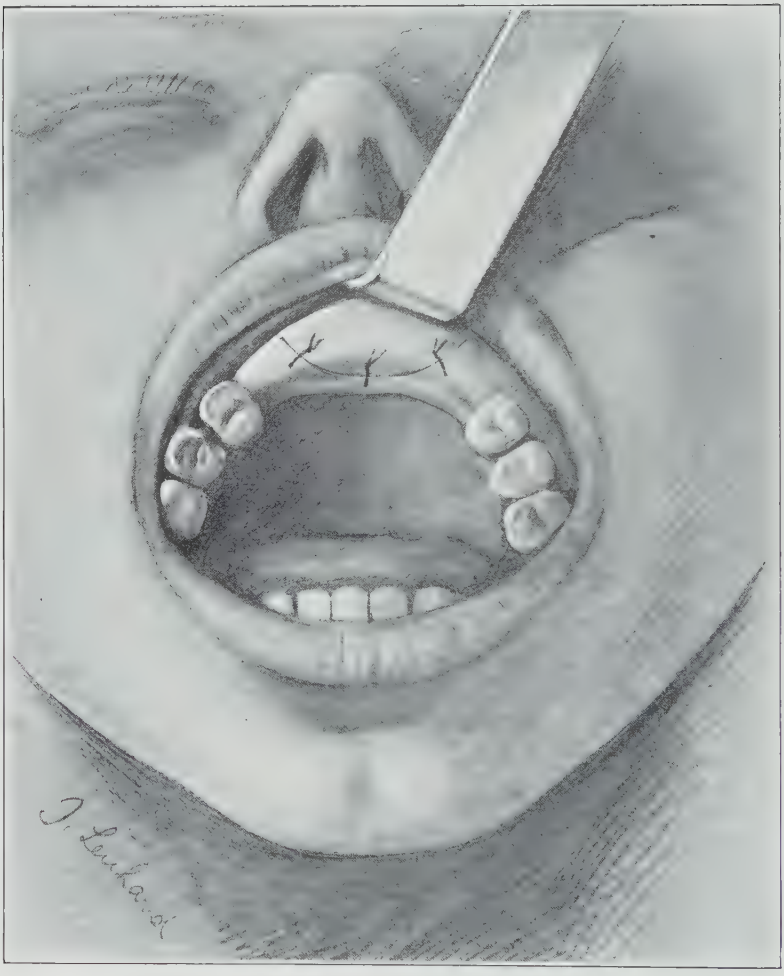


Fig. 94.—Flap brought back and sutured.

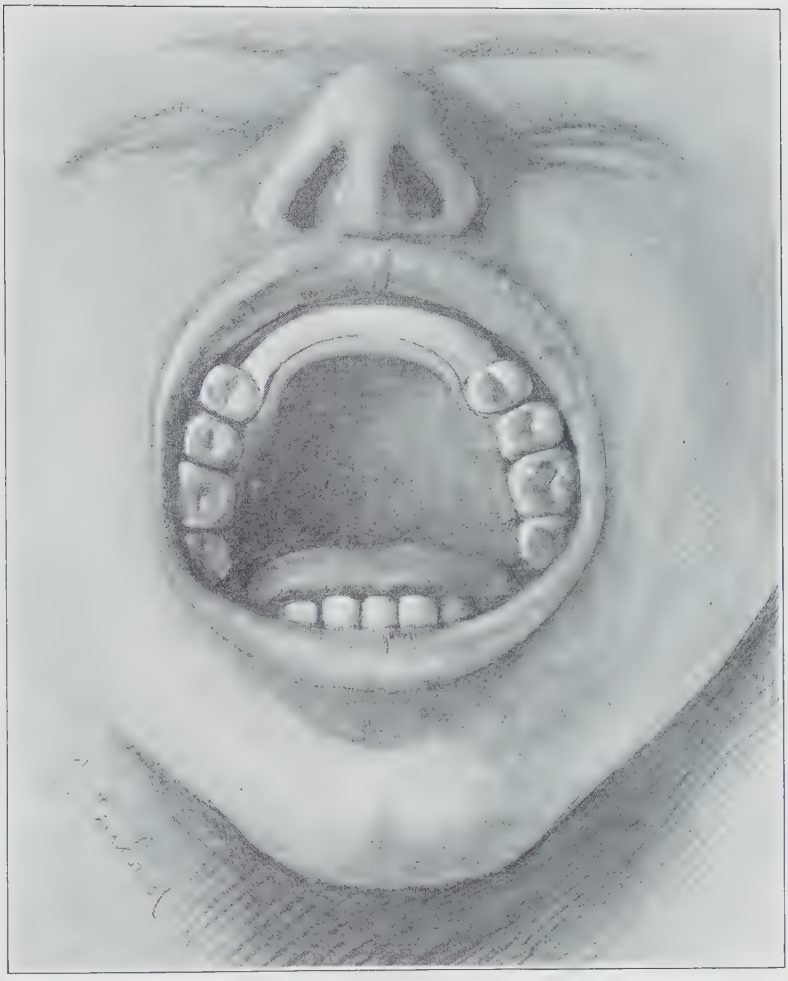


Fig. 95.—Nature of incision for the exposure or removal of impacted anterior teeth, situated palatally.

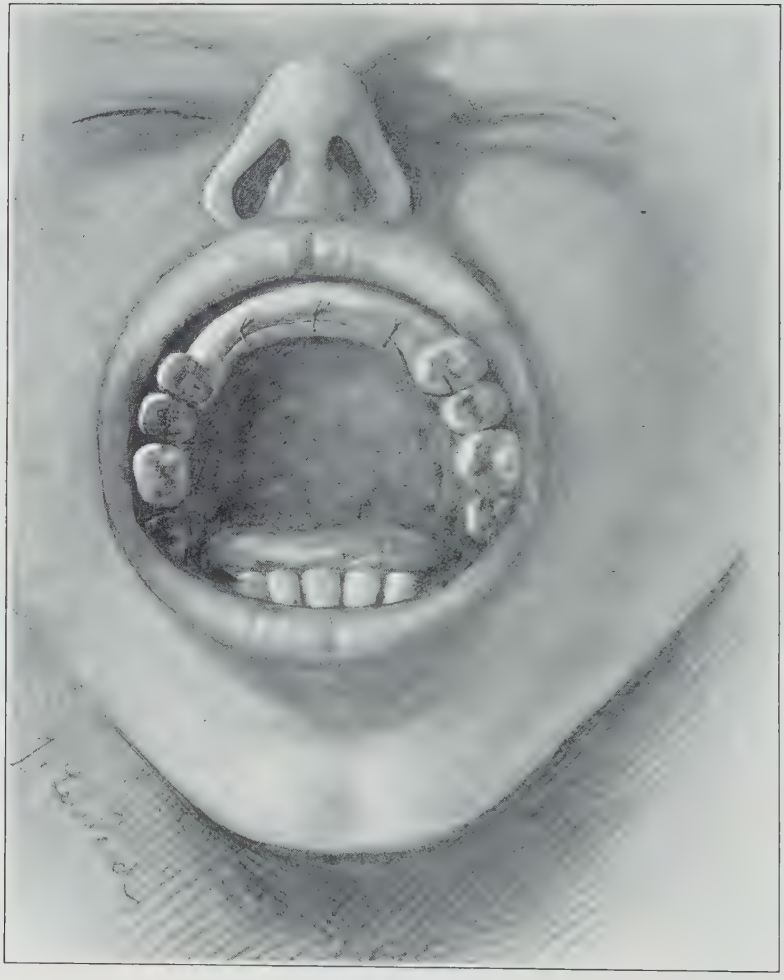


Fig. 96.—Technic of suturing flap.

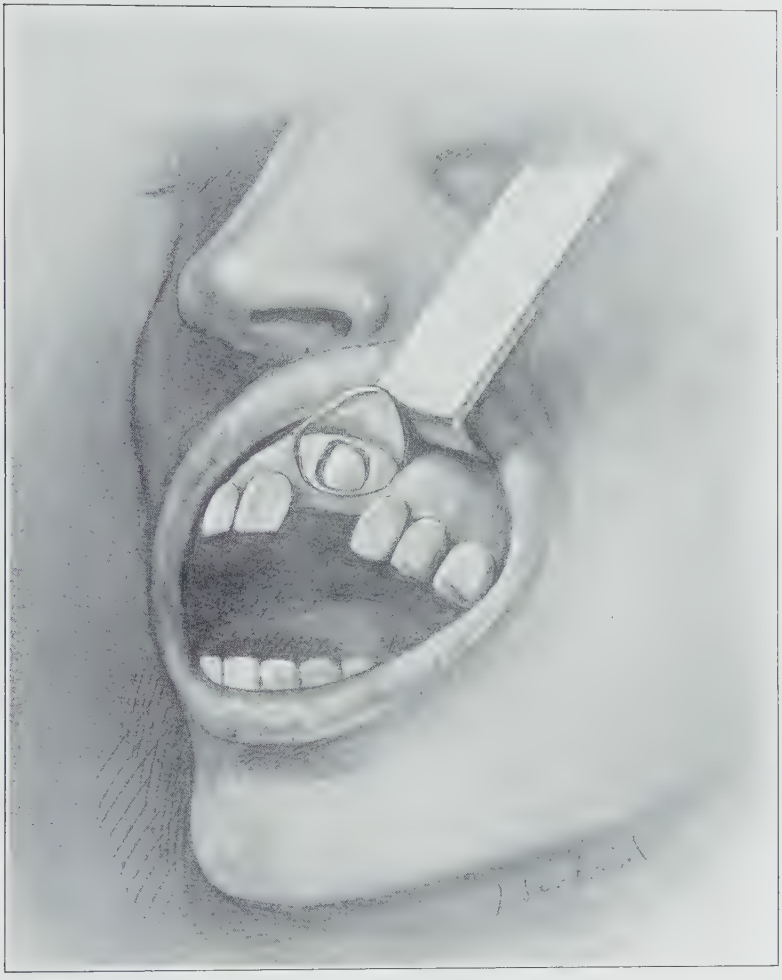


Fig. 97.—Incision for the exposure for orthodontic purposes, or for the removal of an impacted maxillary central incisor.

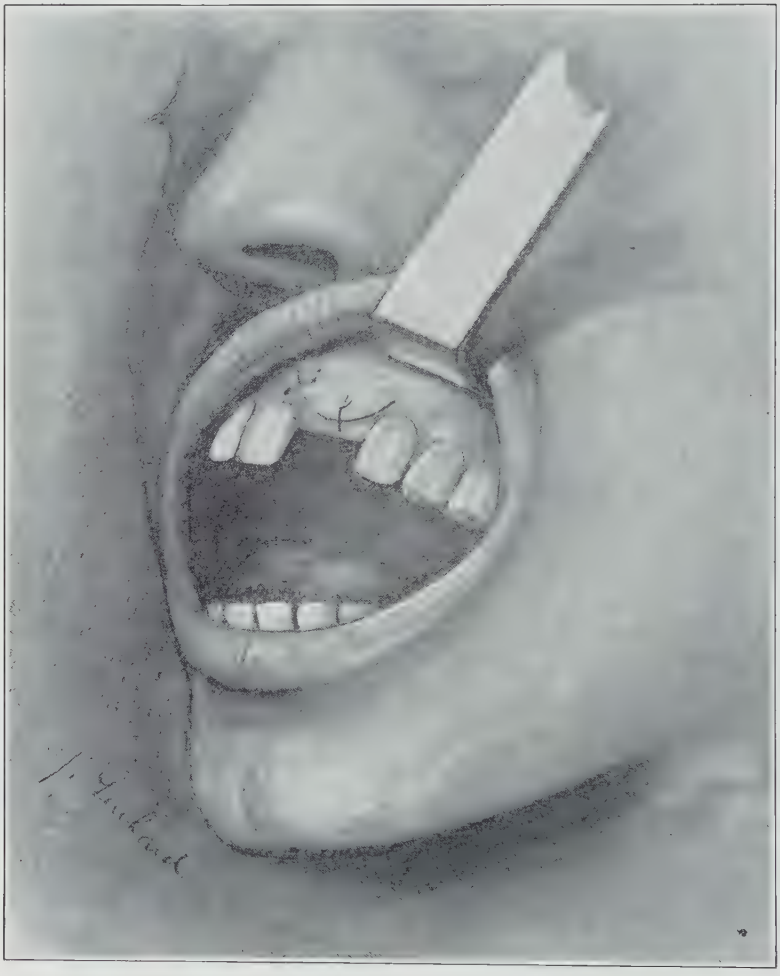


Fig. 98.—The suturing of the flap.

CHAPTER XIX

TECHNIC FOR THE REMOVAL OF IMPACTED MAXILLARY CANINES

Success in the removal of impacted maxillary canines without causing irreparable injury, such as the loss of adjacent teeth, is dependent upon several important factors. Dental literature is replete with descriptions of various technics. However, no one particular method is applicable to all cases. While no standardized technic can be established, owing to the varied positions which some of the teeth occupy, a more or less definite system of operation, based upon the following classification, will greatly facilitate the removal of these units.

Classification

1. **Unilateral Impaction.**—Teeth in arch. Crown situated palatally, and lying close to the gingival margin.

2. **Unilateral Impaction.**—Teeth in arch. Crown situated palatally and at a distance from the gingival margin.

3. **Unilateral Impaction.**—Edentulous Mouth. No evidence by digital palpation of the position of the tooth.

4. **Unilateral Impaction.**—Edentulous Mouth. Evidence by digital palpation of the position of the crown palatally.

5. **Bilateral Impaction.**—Teeth in Arch.

6. **Bilateral Impaction.**—Edentulous Mouth.

When an impacted canine is discovered through routine radiography, and no septic disturbances are present, the patient is advised of the possibilities of orthodontic treatment; that is, provided the case presents favorable conditions; otherwise, removal is advocated.

The removal of the impacted canine is advised when the following conditions present themselves:

1. Prior to the insertion of a restoration in the maxillae, where all teeth are extracted with the exception of the impacted canines. (Pressure may cause injury.)

2. Atypical neuralgia.

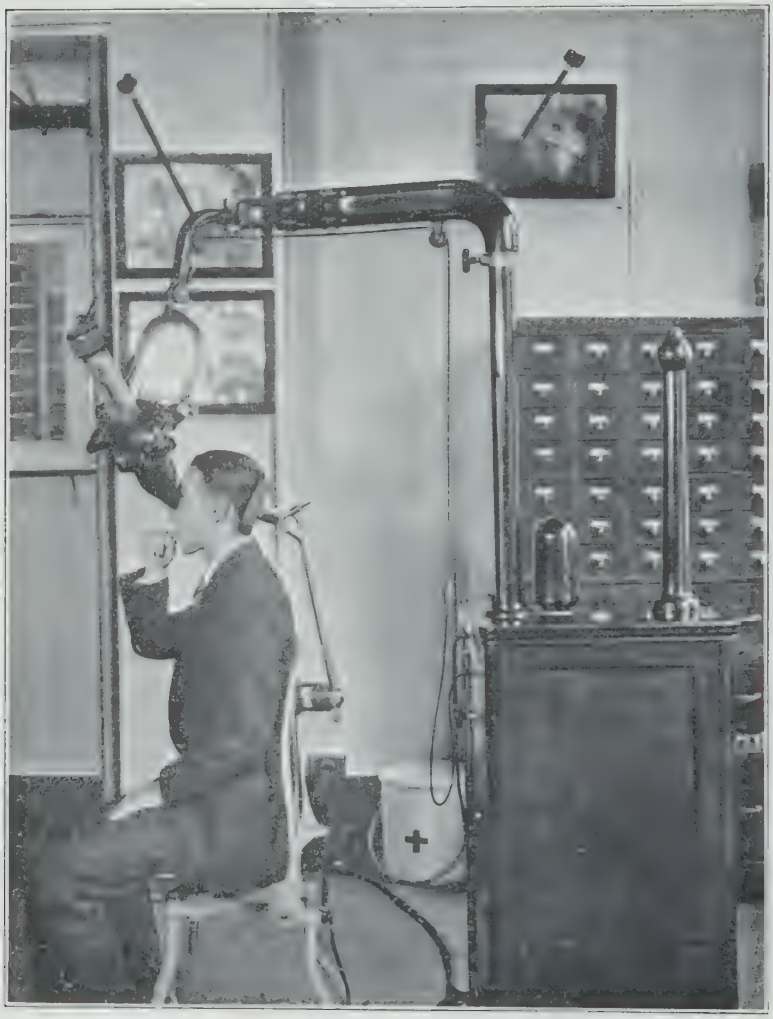


Fig. 99.—Position of tube in using No. 1 dental film. The resultant radiogram will show the relative position of the crown of the impacted tooth to the gingival margin.

3. Systemic involvement of unknown origin.

In the latter instances, the patient should be informed that the tooth is removed only as a precautionary measure to eliminate

all possible dental causes, because the radiogram may fail to reveal the presence of a cyst which usually envelopes the crown in this type of tooth.

Fig. 100.—Position of tube in using the No. 2 film. By this method an accurate localization of the impacted tooth is obtained.

Radiography

The first step in the removal of an impacted canine tooth is the careful study of radiograms. Two types should be taken:

(1) the small dental film (No. 1); (2) the bite film (No. 2). Radiograms should show:

1. The location of the impacted tooth.
2. The position of this tooth.
3. The anatomic relations of the impacted tooth.
4. Type of tooth with which we have to deal, whether normal or not.
5. The pathologic condition of the tooth and surrounding tissues.
6. The condition of the adjacent teeth.

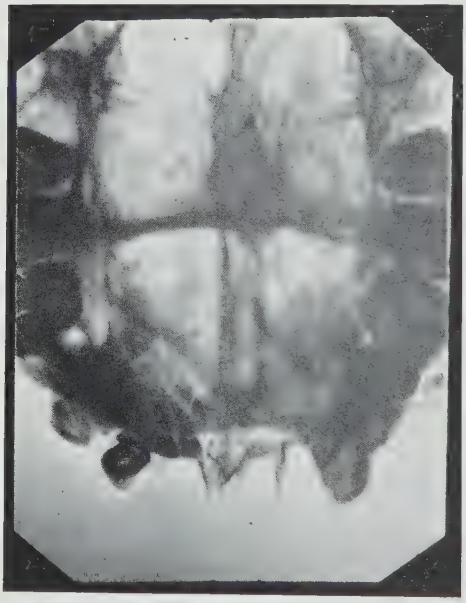


Fig. 101.

Fig. 102.

Figs. 101 and 102.—Comparison of the two forms of radiograms taken on a dry specimen.

The small dental film, when taken at the proper angle, shows the position the crown of the impacted tooth occupies with reference to the gingival margin. This acts as a guide in determining the nature of the incision to be made. This form of film, however, is likely to be very misleading in the localization of the impacted canine. It might appear from this character of picture that the tooth is very superficially located, whereas in the majority of cases it is found to be very deep.

The ordinary x-ray film fails to show whether an unerupted or an impacted tooth is lying buccally or lingually. A stereoscopic radiogram would show the exact location, but the time and great care required by this technic has made it unpopular.

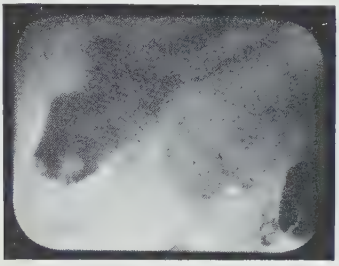


Fig. 103.

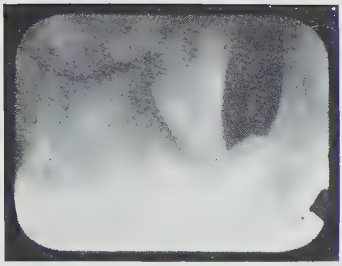


Fig. 104.

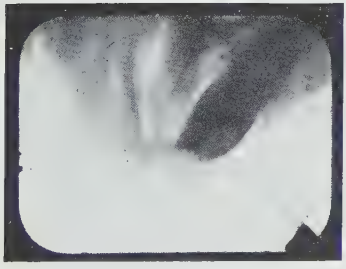


Fig. 105.

Fig. 106.

Figs. 103-106.—Case in which roentgenologist made a written report of three impacted teeth. The large film is the view obtained by the overhead localization method, showing but one tooth impacted.

The best means of radiographic localization is to direct the x-rays in such a manner that a cross section of the tissues under examination will be obtained. This is done by placing a film in the mouth and by having the patient bite down upon it. The

Fig. 107.

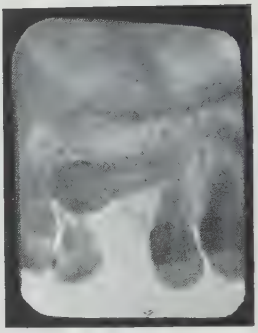


Fig. 108.

Figs. 107 and 108.—Comparison of radiograms of the same case. The small film (No. 108) is misleading for localization. The impacted tooth in this picture appears to be very superficial. The large film (No. 107) shows the true position of the impacted tooth to be diagonal, the crown portion toward the palate, the apex toward the buccal.

Fig. 109.

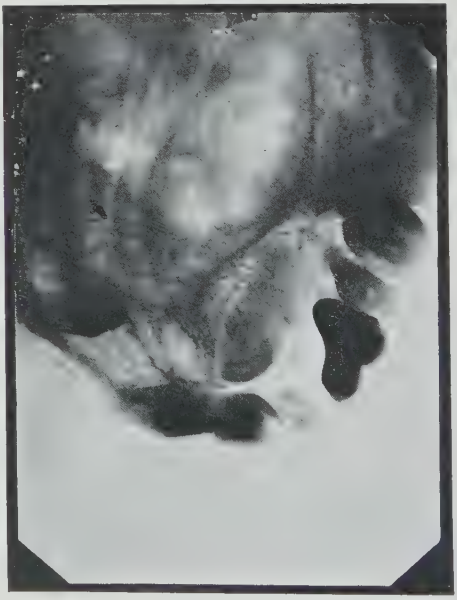


Fig. 110.

Figs. 109 and 110.—Overhead localization. Two radiograms showing the accurate position of the impacted tooth. It may be clearly seen from these pictures that the crown of the impacted tooth lies palatally, the root portion cannot be clearly discerned for it is situated more anteriorly toward the buccal aspect.

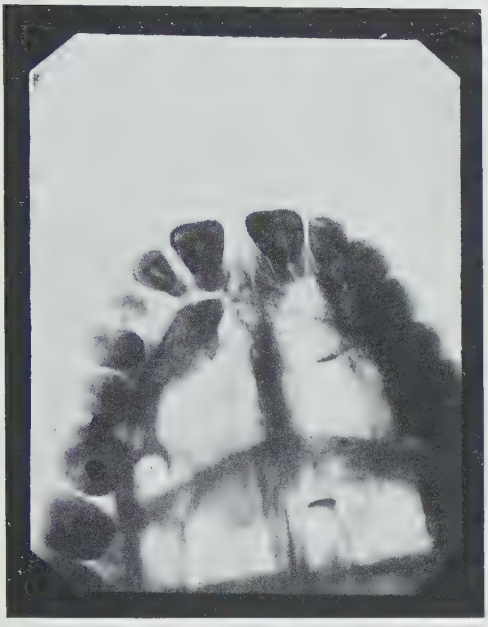


Fig. 111.

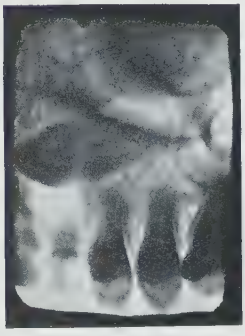


Fig. 112.

Figs. 111 and 112.—Showing cases in which because of the pathology present, teeth in addition to the impacted canines had to be removed in order to clear up the diseased areas. A careful study of the radiograms will reveal just which tooth or teeth it will be necessary to remove. This should be done as a part of the operation for the removal of the impacted tooth.

Fig. 113.—Showing pathology around lateral incisor.

film thus rests between the maxillary and the mandibular arches. If the patient has a marked overbite, which tends to bend the film, it is best to place a piece of metal under the film to keep it straight. The rays are directed approximately at right

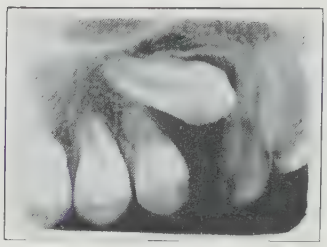


Fig. 114.

Fig. 115.

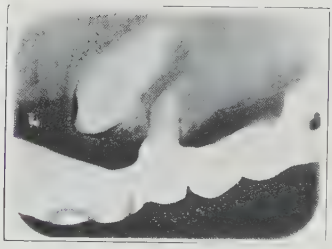


Fig. 116.

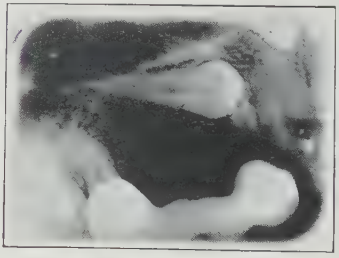


Fig. 117.

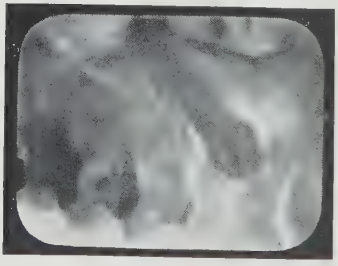


Fig. 118.

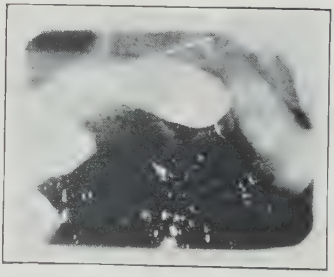


Fig. 119.

Figs. 114-119.—Illustrating cases in which curettage in addition to mere removal of impacted tooth is indicated.

angles to the film and parallel with the long axis of the teeth. The point of entrance of the central x-ray is right through the frontal bone, at and between the frontal sinuses.

Adjusting the tube in this position instead of at the top of the head, places this technic within reach of the average dentist.

When the rays are directed through the top of the skull the machine must be backing up 4.5 to 5 inches of spark-gap. The machines in the hands of most dentists are of the 3.5 inch, 10 milliampere variety, sufficient for the first method described, but will not be insufficient when used for the position described by Dr. C. O. Simpson. It can readily be seen how this manner of localization works to the advantage of most of the dental pro-

Fig. 120.—Type of shadowless lamp which serves admirably for mouth operations.

fession, in using the 3.5 inch 10 milliampere machine at a target film distance of 15 inches with an extra fast film. We would expose from 8 to 10 seconds.

When it is ascertained through radiographic findings that the pathologic conditions present make it necessary to remove other teeth with the impacted canine, the patient should be so advised. It is best that the tooth or teeth be removed at the same sitting, rather than at a subsequent operation. Very often this procedure facilitates the operation. It must, however, be made clear that

it is not necessary to remove any sound tooth or teeth for the purpose of gaining access to the impacted tooth.

The use of only a small film at different angles is apt to portray an erroneous outline of the crown portion, so much so that it may be interpreted as another tooth. A recent case is that of a patient who was referred to me for the removal of three impacted teeth. The patient presented radiograms with a written interpretation. The conclusion, after examining the radiograms,

Fig. 121.—Incision to be made in single impaction cases where the crown of the impacted tooth lies close to the gingival margin, and in cases of double impactions regardless of the distance between the gingival margin and the crowns of the impacted teeth.

was that only one tooth was impacted. In order to confirm this judgment, a No. 2 bite film was used as previously described. The radiographic finding verified my decision.

At a recent oral surgery clinic, the clinician, prior to the operation, cautioned the audience against attempts to operate without good radiograms. However, he used only a small film and, after twenty minutes of vain effort on the right maxillae, he decided to open the left side and there lay the impacted tooth.

In speaking of the impacted teeth lying buccally or palatally, reference is made to the crown position only. In practically all cases the impacted tooth lies diagonally, the crown portion toward the palate, and the apex toward the buccal surface.

Technic of Operation.—Asepsis and anesthesia are vital factors for the success of any operation. Our aim is to secure the highest degree of asepsis that is humanly possible, although in

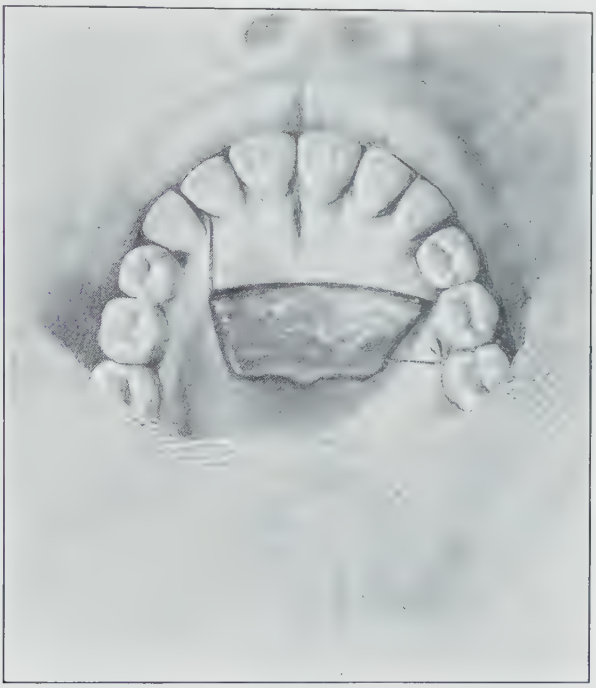


Fig. 122.—Mucoperiosteal flap including the gingiva retracted and held in position by the aid of a double horsehair suture tied to a molar tooth. The insertion of a broad periosteal elevator into the incision, and exerting force upward and outward will facilitate the separation of the soft structures from the bone and prevent any laceration.

oral surgery this cannot be maintained analogous to abdominal operations. Even though many operators think they can disregard asepsis because the oral cavity contains innumerable bacteria, we must, however, prevent the introduction of foreign bacteria. Sterile gauze and sterile linen are as essential as sterile instruments. The use of absorbent cotton, shaped into sponge forms, rather than the use of sterile gauze, is contrary to correct surgical procedure. A sterile towel should be draped

around the patient's head, to preserve the sterility of the operator's hands, or should occasion arise for a subsequent adjustment of the patient's head. There should also be a sterile towel for a final covering of the patient to avoid contamination of gauze which may come in contact with the patient's chest.

Preparation of the Field of Operation.—The technic consists first in spraying out the mouth with an antiseptic solution; the lip is then held away from the gum, and with sterile gauze

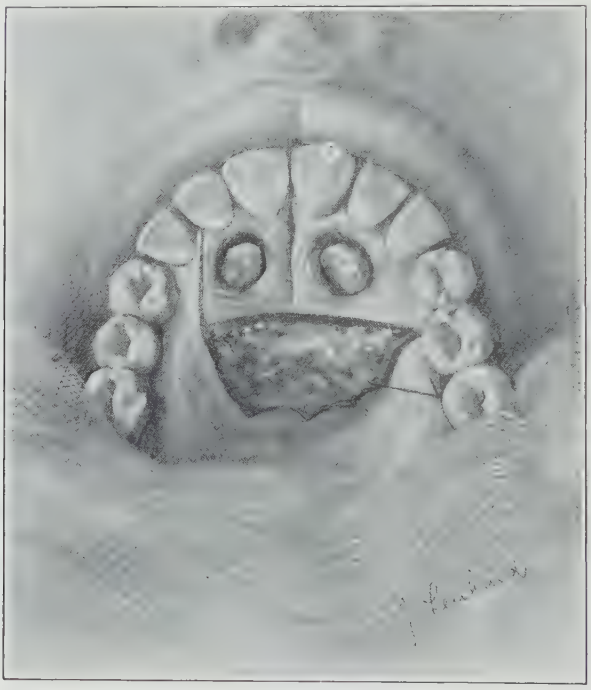


Fig. 123.—Showing sufficient bone removed over the coronal portion to permit of the insertion of a spear-pointed elevator.

sponges all mucus is wiped from the field of operation. Then, with a cotton applicator, dipped in a solution of aconite and iodine, the area to be injected into and operated upon should be painted.

Anesthesia.—Novocaine-suprarenin is unquestionably the best anesthetic to use in operations of this nature. Particular attention should be paid to the paraphernalia for producing anesthesia. A sterile solution, a sterile syringe, and a sterile needle

will obviate any possibility of unnecessary suffering to the patient, and will relieve the operator of considerable anxiety.

By the use of a sterile solution of novocaine-suprarenin the continuity of surgical asepsis above mentioned is assured. By its use, we obtain a comparatively ischemic area, more pronounced with the "E" than with the "T" formula. In using local novocaine anesthesia we obtain the cooperation of the patient which is a valuable adjunct.

Fig. 124.—Showing teeth removed and all sharp edges of bone made smooth.

A 2 per cent solution of novocaine-suprarenin may be used with perfect safety, although it will be found that in the hands of the experienced operator lesser concentrations, from 1 to 1.5 per cent, will give equally perfect anesthesia.

An injection into the anterior palatine foramen, with slight infiltration in the region of the impacted canines and first premolars, augmented by infiltration of the buccal aspect on each side, will insure perfect anesthesia. If the patient is nervously

inclined, the administration of camphorated validol, 7 to 8 gtt., fifteen to twenty minutes prior to the operation, will generally quiet him.

Technic for Unilateral Impacted Canine Crown Situated Palatally and Lying Close to the Gingival Margin. (Classification No. 1.)

When the number one dental film shows the crown of the impacted tooth to be lying close to the gingival margin, an inci-

Fig. 125.—Flap placed back into position. No sutures necessary, because of the presence of all teeth in area involved.

sion including the gingival margin should be made. An incision is made distally to the lateral incisor on the side opposite the impaction. Extend the incision posteriorly on the hard palate in a vertical line, to approximately the second premolar. Carefully insert a broad periosteal elevator and separate the mucoperiosteal flap, including the gingival margins of the teeth involved, from the bone. The flap may be held in position by passing a horsehair suture through it and fastening the suture

to a molar tooth. The overlying bone is carefully removed with mastoid gouges or bone burs, for approximately two-thirds of the length of the tooth, commencing at the coronal end. A fine spear-pointed elevator is inserted under the crown, and instead of attempting hand pressure, the elevator is gently malleted. If resistance is met in the attempt to dislodge, more bone should be removed.

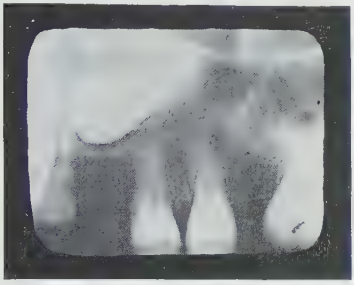
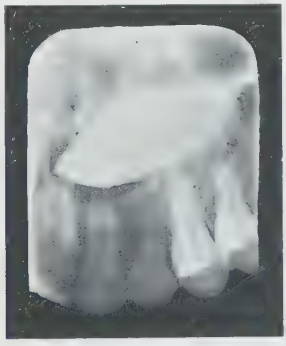


Fig. 126.

Fig. 127.

Figs. 126 and 127.—Types of cases in which a semilunar or semicircular incision may be used. Note distance of the crown of the impacted tooth from the gingival margin.



Figs. 128 and 129.—Case in which a semilunar incision may be used, owing to the distance of the crown from the gingival margin.

In using the spear-pointed elevator, the leverage should be on the palatal process of the maxilla, and not on the teeth in the arch. Should the crown portion break off, or a portion of the root still remain, great care should be taken in the removal of this fragment. The wound should be thoroughly dried and, by the aid of a good light, a clear view of the root obtained. A

fissure or round bur should then be used to remove the bone around the root, after which the root may be dislodged with little difficulty. All soft materials should then be removed by the careful use of the curette, the edges of the bone should be made smooth, and the wound irrigated with an antiseptic, preferably an iodine solution one-fortieth of 1 per cent. The flap is then replaced. Sutures are used only where teeth are missing. Where there are no sutures used, a pad of gauze, the size of a

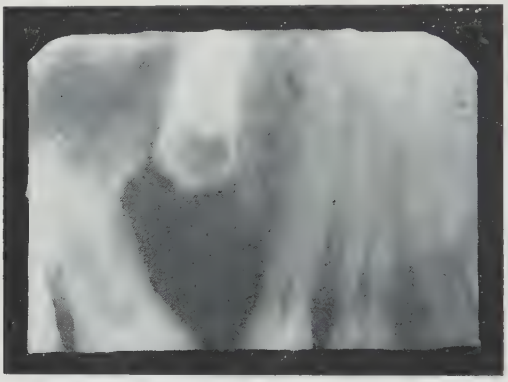


Fig. 130.—Impacted canine. Teeth in arch—caries in crown portion.

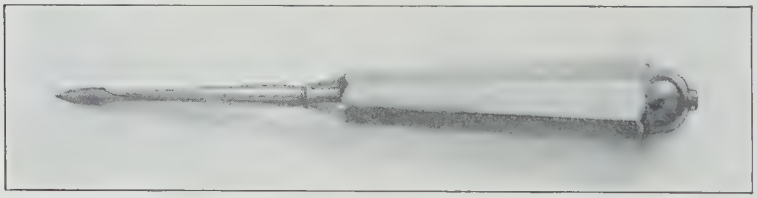


Fig. 131.—Spear-pointed elevator with steel rod running through it and extending from posterior surface to receive the blows of the mallet.

tonsil sponge, is placed on the palate after the flap is in position. The gauze is then pressed against the palate by closing the mouth and it is held in position for approximately ten minutes.

Suturing in these cases is best accomplished with fine curved needles and sterile horsehair. This combination eliminates tearing the mucous membrane. Sutures should not be removed until at least six days following the operation.

It must be clearly borne in mind that our efforts must be directed toward exposing the crown of the impacted tooth, for

that is the portion of the largest diameter. It may be readily conceived then, that where the radiogram reveals the presence of the crown close to the gingival margin, and a semicircular incision is made, there will unquestionably be a laceration of the mucous membrane from the incision to the gingival margin in the attempt to expose the crown. In most instances this results in sloughing.

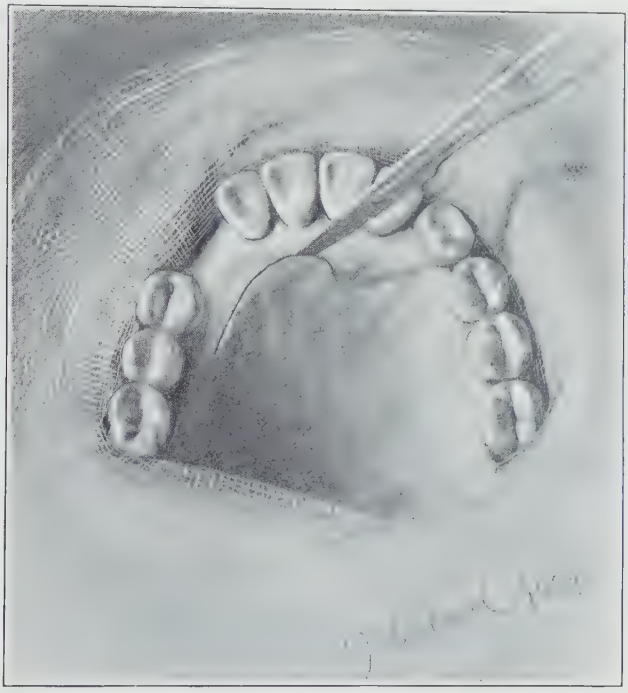


Fig. 132.—Semilunar or semicircular incision to be used only in single impacted canines, where crown lies sufficient distance from gingival margin.

The handles of the spear-pointed elevator should have a steel rod running through the center. The ordinary elevator, when subjected to malleting, usually becomes indented; cracks thus produced permit the entrance of water during sterilization. The slightest tapping with the mallet causes the expulsion of water. This condition is disagreeable both to the patient and to the operator and is not in conformity with asepsis.

Technic for Unilateral Impaction—Teeth in Arch. Crown Palatally and at a Distance from the Gingival Margin. (Classification No. 2.)

The radiograms should be carefully studied to see whether the crown portion lies palatally. The small film will aid in determining the proximity of the impacted crown to the gingival margin. If there is sufficient distance between the crown and

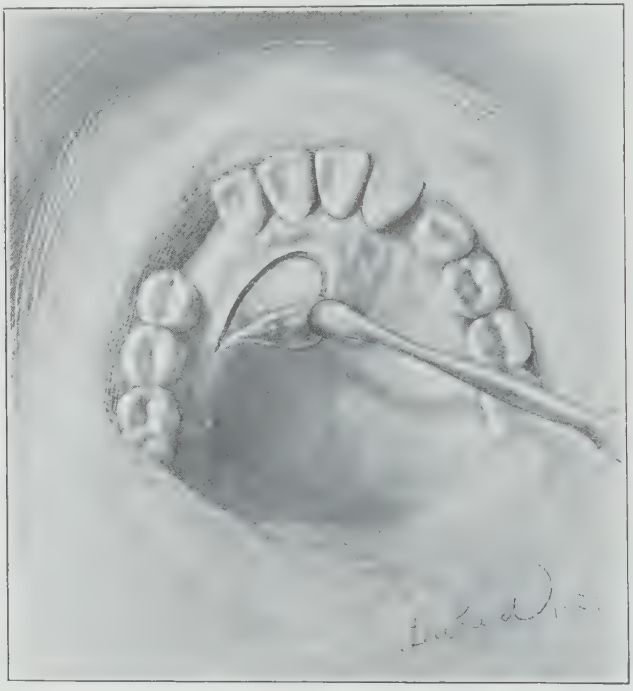


Fig. 133.—Elevation of mucoperiosteal flap. Type of periosteal elevator best adaptable for these operations is also shown.

the gingival margin, a semilunar or semicircular incision is made parallel to the gingiva. A sufficiently broad span of tissue must be allowed between the incision and gingiva for the following reasons:

1. To provide for an unobstructed view of the crown after the overlying bone has been removed.

2. To be able to suture without destroying the tissue between the incision and the necks of the teeth.

A semilunar or semicircular incision is made. No fear need be entertained in making a good-sized incision. Most failures

Fig. 134.—Showing sufficient amount of bone covering the tooth removed to permit of its removal by means of an elevator or thin-beaked forceps.

Fig. 135.—Tooth removed, area curetted and all sharp edges made smooth.

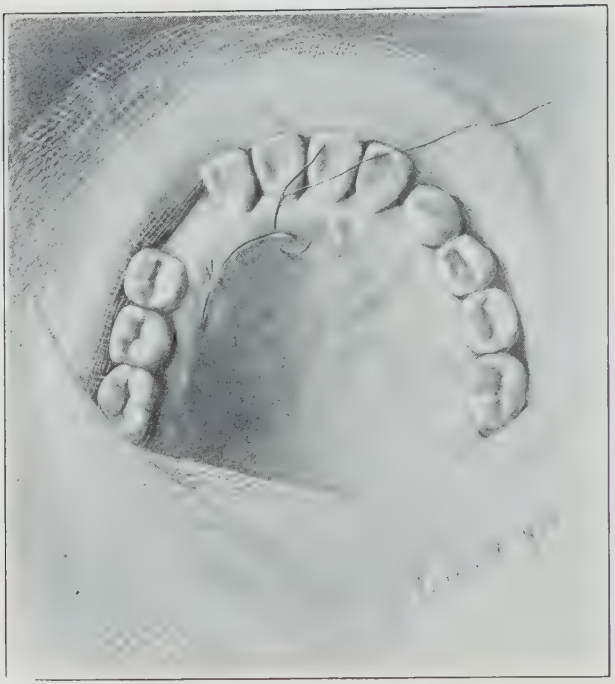


Fig. 136.—Showing technic of inserting sutures. Care should be taken to insert the needle a safe distance from the incision on each side, to prevent tearing of the mucous membrane.

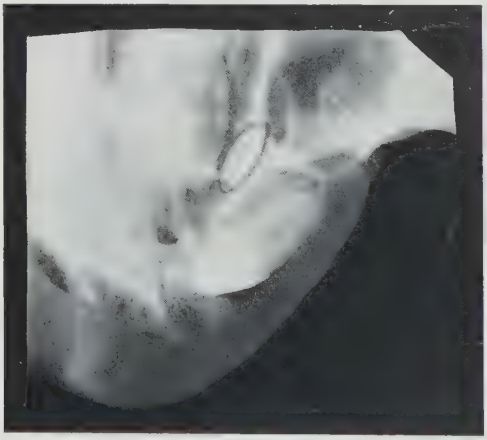


Fig. 137.

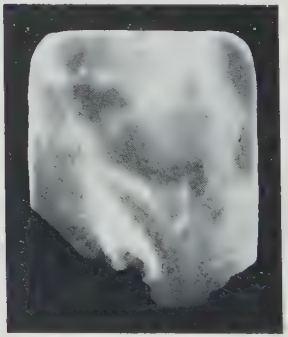


Fig. 138.

Fig. 137.—Single impacted canine—edentulous mouth. This tooth may be removed from the buccal aspect or by way of the palate. The removal by way of the buccal aspect is preferable.

Fig. 138.—Impacted canine, edentulous mouth, caries in crown portion.

Fig. 139.—Nature of the incision for the removal of an impacted maxillary canine, edentulous mouth, from the buccal aspect. The incision should be made to the side of the frenum labium.

Fig. 140.—Showing the retraction of the mucoperiosteal flap.

result from the incision being too small, rather than too large. The exact extent of the incision must be determined from the radiogram. In the average case the crown portion approximates the mesial surface of the lateral incisor. Therefore, an incision extending from the mesial surface of the central incisor to a point approximately opposite the second premolar would give an unobstructed view of the field of operation. Round surgical burs will be found to be most expedient in removing the bone

Fig. 141.—Position of the mastoid gouge in beginning the removal of the overlying bone. The bone covering the superior border of the impacted tooth should first be removed.

overlying the crown in these cases. The subsequent operative technic is analogous to the previous operation, with the exception of the suturing.

Technic of Operation for Impacted Maxillary Canine—Edentulous Mouth. No Evidence by Digital Palpation of the Position of the Tooth. (Classification No. 3.)

By digital palpation an endeavor should be made to determine whether the tooth can be felt palatally or buccally. If this

Fig. 142.—Showing two-thirds of the tooth exposed, a sufficient amount to permit of its removal by means of extracting forceps or an elevator.

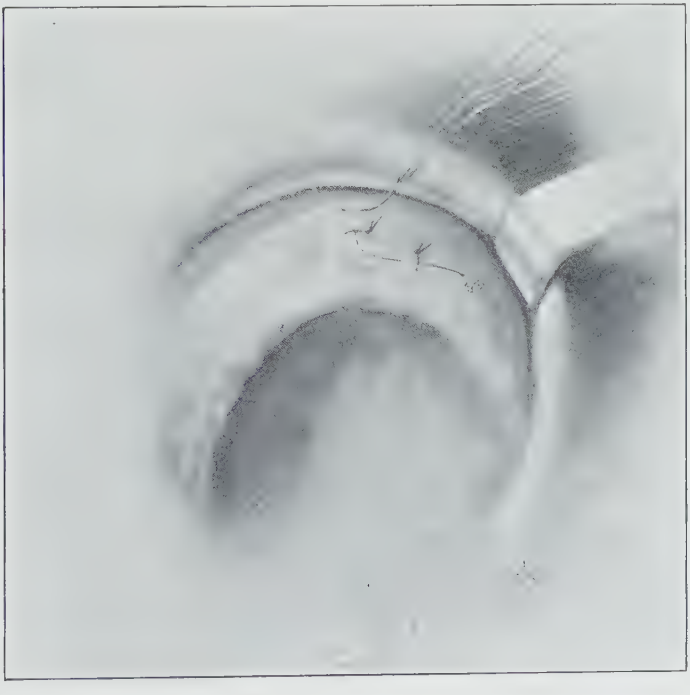


Fig. 143.—Showing technic of suturing. The use of three sutures will generally be sufficient in this form of incision.

method fails to disclose the outline of a tooth, it is reasonable to suppose that the tooth lies between the buccal and lingual plates of bone. Under the latter circumstance the choice of the modus operandi must be taken into consideration. The advantages and disadvantages of opening either palatally or buccally are as follows:

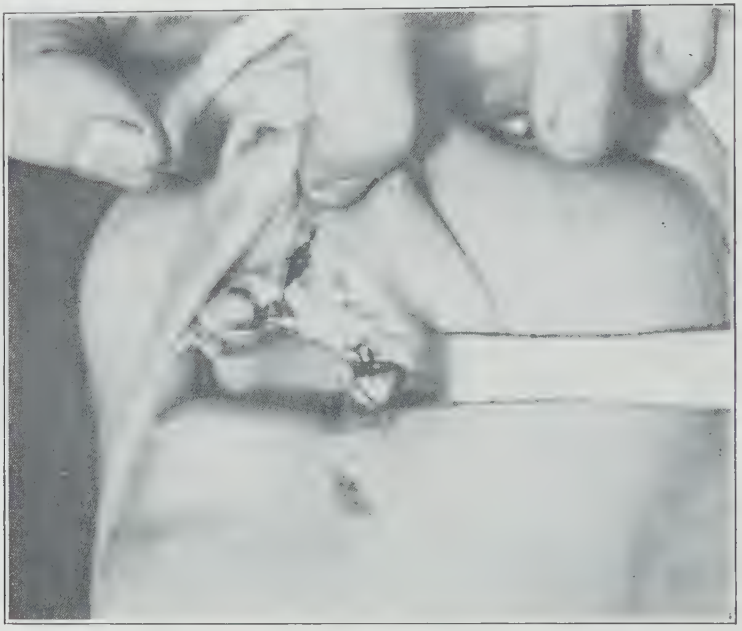


Fig. 144.

Figs. 144-147.—Case illustrating the necessity of exposing the apex, because of its peculiar curve before tooth could be dislodged.

Advantages from buccal opening:

1. Better view of operative field.
2. Assistance in retraction of lip.
3. Cooperation of patient not required in connection with opening the mouth.

Disadvantages:

1. Possibility of postoperative edema (due to the presence of loose cellular tissue beneath the orbit).

Advantages from palatal aspect:

1. The elimination of postoperative edema.
2. Little postoperative treatment.

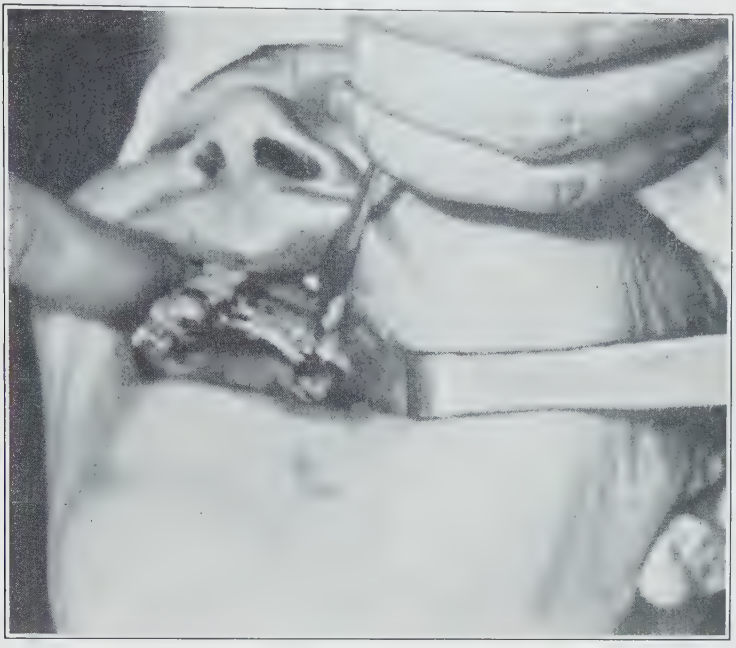


Fig. 145.

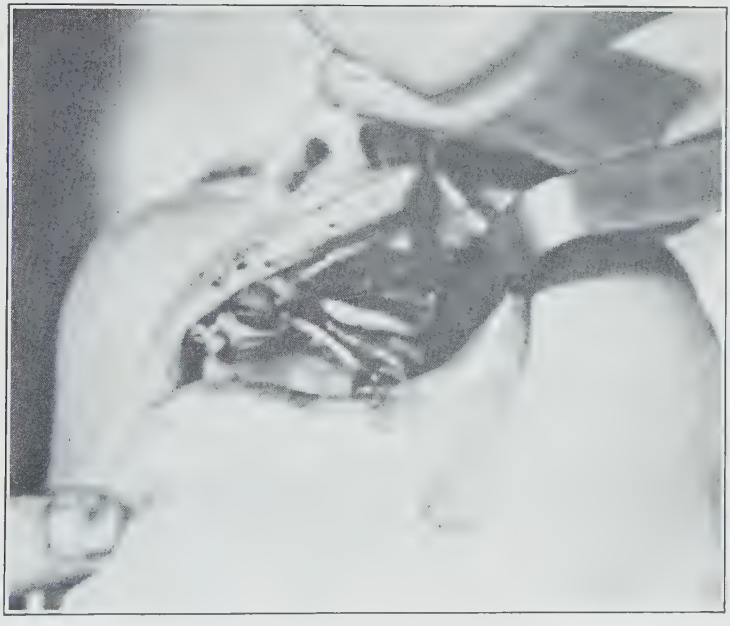


Fig. 146.

Disadvantages:

1. Lack of proper light to illuminate the field of operation.
2. The need of the constant cooperation of the patient.

When a distinct bulge manifests itself, the operator has no alternative. The incision is made on the side of the protrusion.

The operation of choice in these cases would be buccally, unless digital palpation disclosed the tooth to lie on the palatal aspect.

Incisions should be made with a sharp knife. The Bard-Parker Blade No. 11 is recommended for this purpose. Make a

Fig. 147.

vertical incision, cutting down through the mucous membrane and periosteum to the bone above the ridge. Continue horizontally for a short distance toward the posterior. Care should be taken not to tear the mucous membrane or to cut the frenum labium. Elevate the mucoperiosteal flap with a periosteal elevator and retract the tissues with a retractor or periosteal elevator. Swab the area carefully with sterile gauze sponges to aid in clarifying the field.

Remove a portion of the outer plate, beginning at least a quarter of an inch above the ridge to avoid mutilation for the prosthetist; continue upwards until two-thirds of the tooth is exposed. Remove all spicula of bone which have become loosened. Place a spear-pointed elevator in position, directing the force upward. Undue force should not be exercised if difficulty

is encountered in dislodging the tooth. Fracture of the alveolar process may be the result of the indiscriminate use of force. Rather than resort to the continued use of force with an elevator or forceps, it is better, when a partly exposed tooth offers resistance to its removal, to remove more of the overlying bone, even to the extent of exposing the apical end. In many instances we may have to contend with a curved root which is not discernible in the radiogram. The bone may be removed either with various sizes of mastoid gouges or by means of round and cross cut fissure surgical burs. In using burs, care should be taken not to start the engine until the bur is in position on the particular portion of bone which is to be removed. In using the dental engine, care must be taken not to overheat the burs.

Irrigate and suture the wound after the tooth is removed. If there is a tendency toward excessive bleeding, insert a dressing of one-half inch strip of 5 per cent iodoform gauze in the posterior portion of the wound.

Remove the dressing after forty-eight hours, after which time there will be no further necessity for it. Irrigation of the wound every forty-eight to seventy-two hours will facilitate the healing process.

Single Impaction—Edentulous Mouth. Evidence by Digital Palpation of the Position of the Crown Palatally. (Classification No. 4.)

Make an incision directly on the ridge extending from the premolar area to the premolar area of the opposite side. The incision should be made down to the bone. Then the soft structures are separated from the bone by a broad periosteal elevator. The flap is then either held posteriorly or a suture of catgut or of horsehair is passed through it and the flap is held aside. In these cases, the bone covering the crowns of the impacted teeth is usually very thin and permits of its removal without much resistance. Mastoid gouges, flat chisels or round bone burs may be used. After exposing a little more than the crown of the tooth, an attempt may be made to grasp the crown with a pair of thin-beaked forceps for maxillary teeth, or the tooth can be raised by the use of an elevator. Following the removal of the

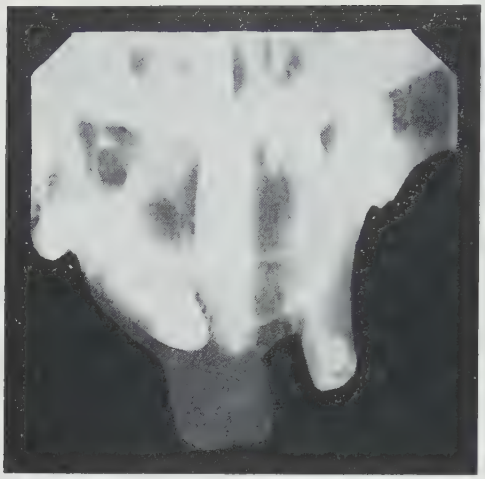


Fig. 148.

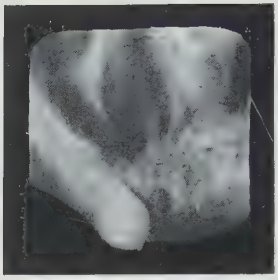


Fig. 149.

Figs. 148 and 149.—Comparison of the two types of radiograms of an impacted canine which upon digital palpation gave evidence of its position palatally.

Fig. 150.—Nature of incision used in unilateral or bilateral impactions in edentulous mouths, where the palatal route is decided upon. Incision is made directly on the ridge, cutting down to the bone, extending from premolar to premolar area.

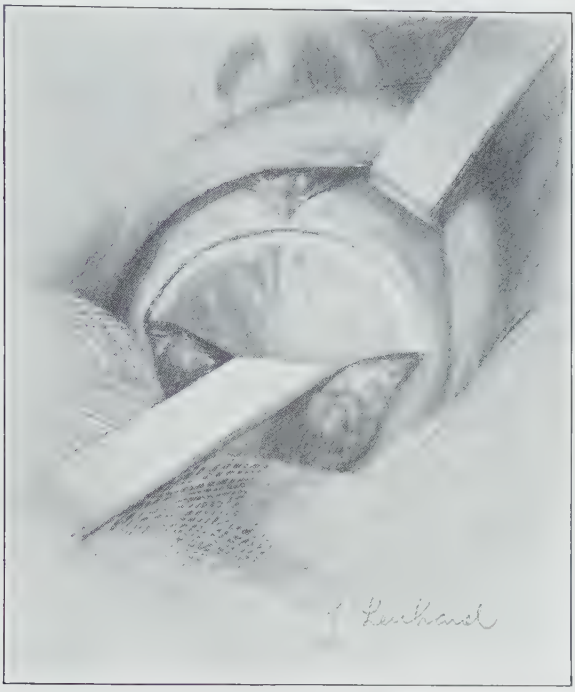


Fig. 151.—Showing the separation of the mucoperiosteal flap from the bone.

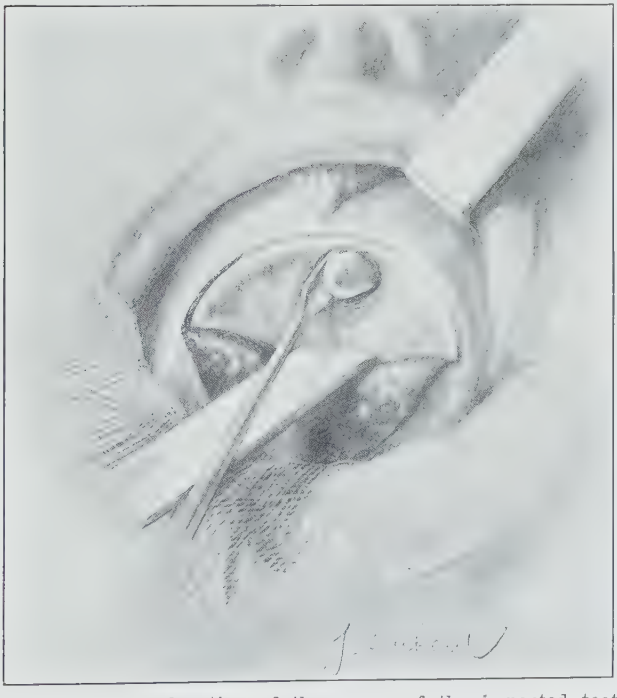


Fig. 152.—Showing the elevation of the crown of the impacted tooth, after the overlying bone had been removed. The force exerted by the elevator should be toward the palate, and not toward the ridge.

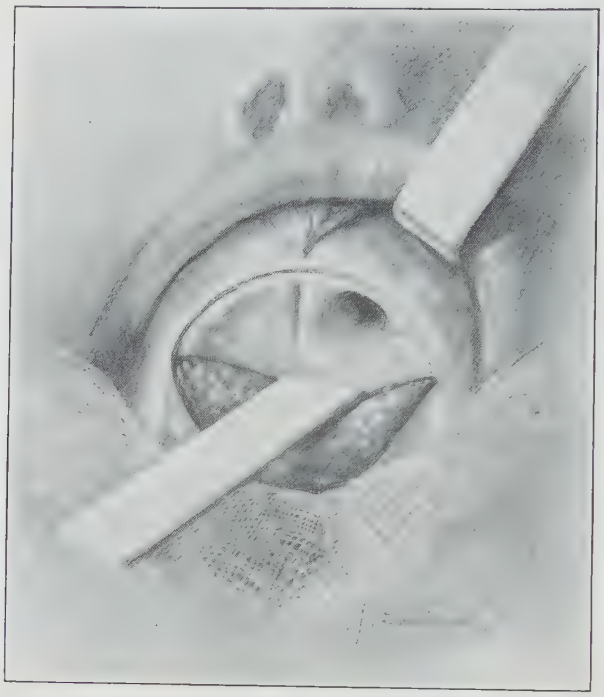


Fig. 153.—Tooth removed, with ridge intact.

Fig. 154.—Showing wound sutured. Care should be taken in approximating the lips of the wound prior to suturing, to have them turned outward.

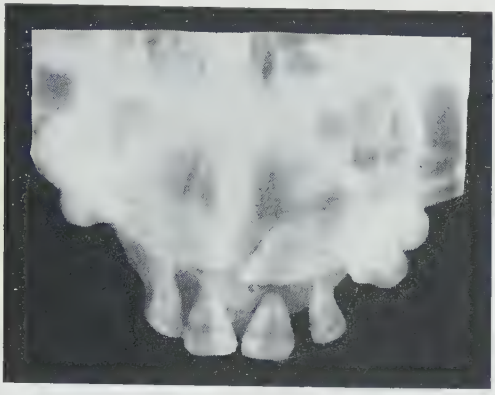


Fig. 155.

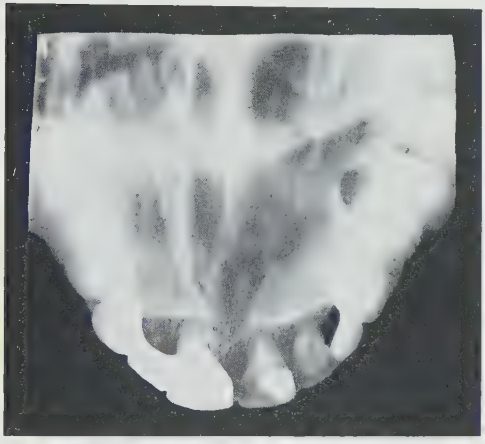


Fig. 156.

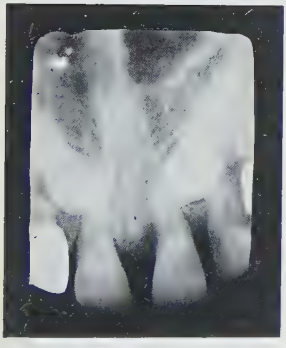


Fig. 157.

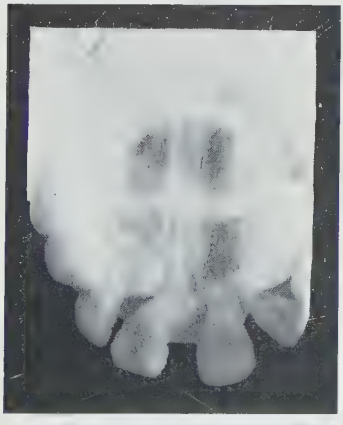


Fig. 158.

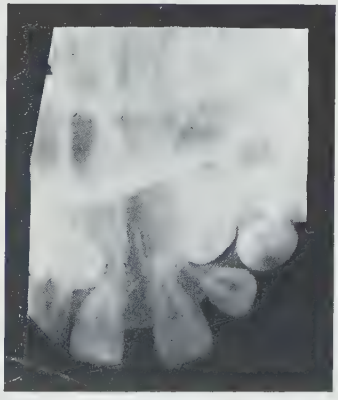


Fig. 159.

Figs. 155 to 159.—Bilateral impacted canines, showing varying degrees of divergence of the coronal portion.

Fig. 160.—Incision for bilateral impaction. Teeth in arch. Crowns of the impacted teeth almost in opposition.

tooth, all sharp and roughened surfaces should be made smooth, and the wound irrigated and sutured. In separating the muco-periosteal flap from the bone it is necessary to sever the anterior palatine vessels in order to overcome any resistance.

Fig. 161.—Elevation of the mucoperiosteal flap.

Bilateral Impaction—Teeth in Arch. (Classification No. 5.)

The incision involving the gingival margins of the teeth, as described, for the single impacted canine lying close to the gingival margin, should be made in these cases. This technic is advocated for cases of bilateral impactions irrespective of the distance of the coronal portion of the teeth in relationship to the gingival margin.

The two-stage operation for the removal of bilateral impacted canines should be discouraged. The operation is best accom-

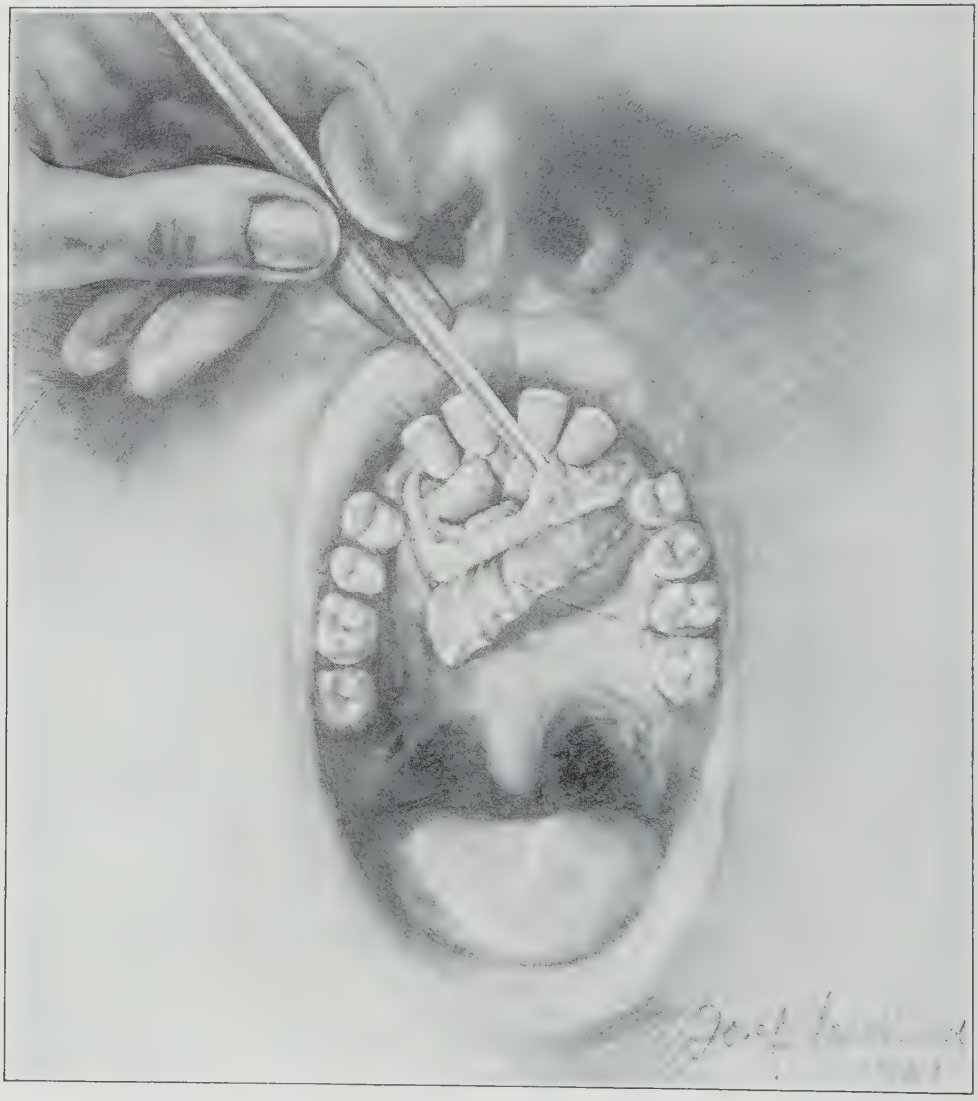


Fig. 162.—Showing position of the mastoid gouges, used in removing the overlying bone.

plished in one sitting and with a single incision. In some cases it becomes necessary to modify an incision, extending it distally to the canine or premolar, depending upon the divergence of the

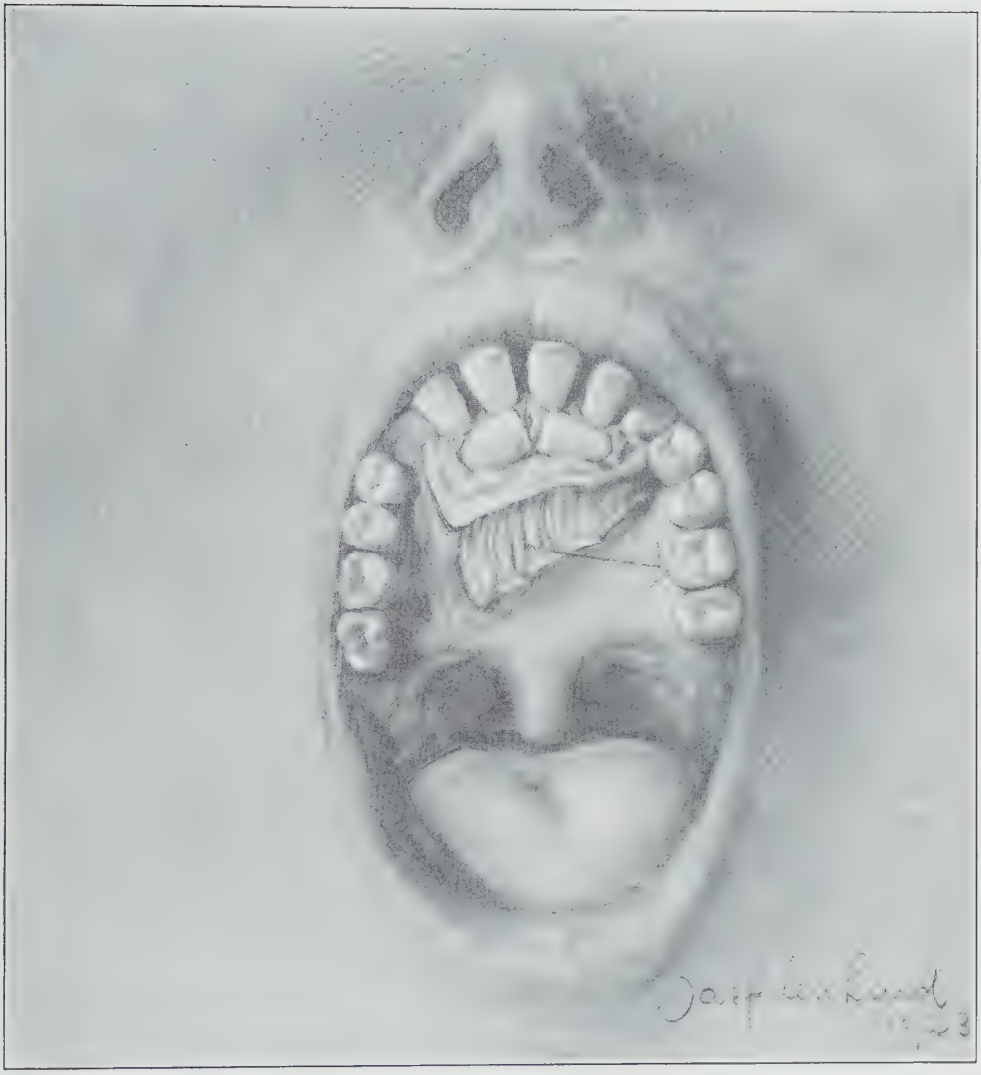


Fig. 163.—Showing sufficient portion of teeth exposed to permit of their removal.

crowns of the impacted teeth. By the use of the single injection, we are enabled in those cases where the crowns of the teeth are not in opposition, to conserve a bridge of bone in the median line, thereby eliminating any depression in the palate.

Fig. 164.—Teeth removed. The illustration shows that by using a single incision for bilateral impacted canines, we are enabled, because of the excellent view of the field of operation, to conserve a bridge of bone in the median line. Through the conservation of this bridge of bone, we have a support for the flap, and the absence of a depression in the anterior portion of the palate.

Bilateral Impaction—Edentulous Mouth. (Classification No. 6.)

These cases are best operated upon by way of the palate. The incision and technic of the operation are exactly the same as for the single impacted canine palatal method.

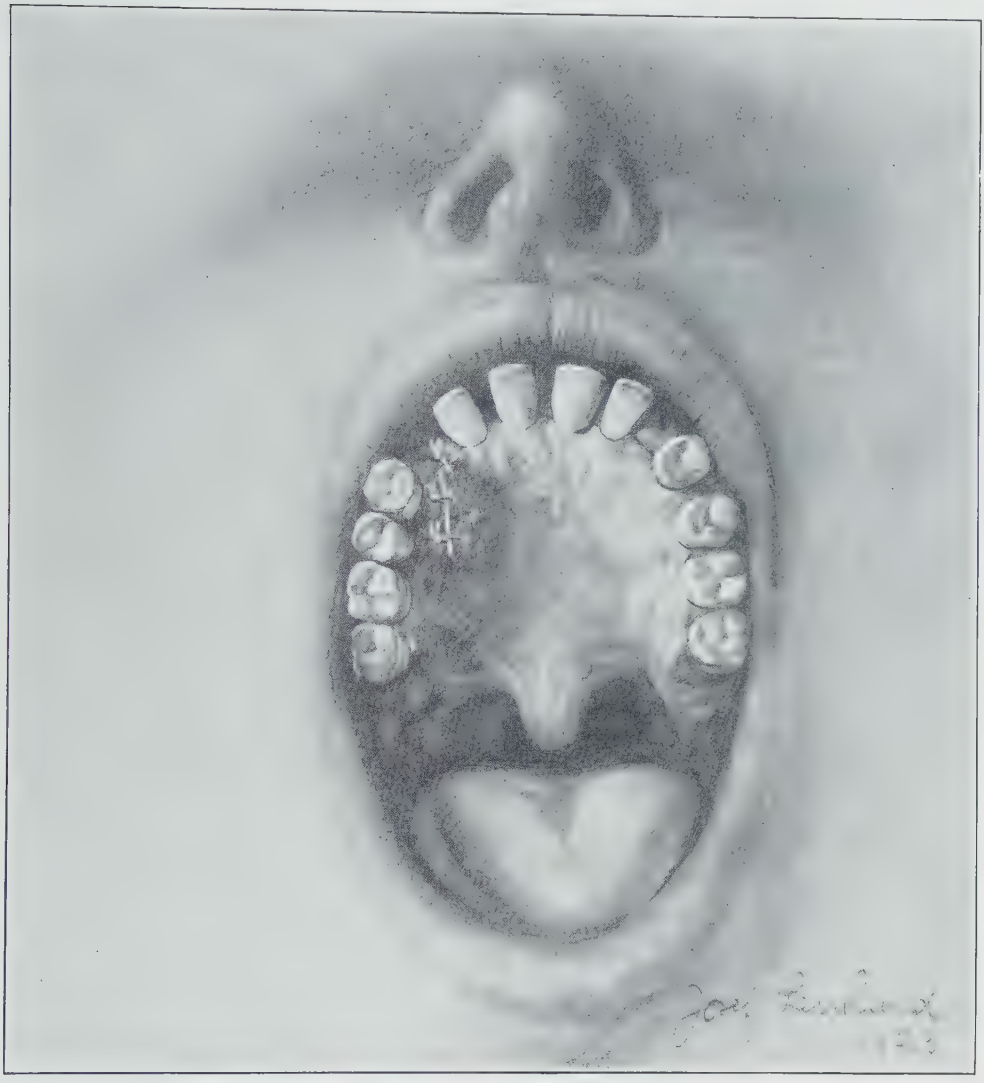


Fig. 165.—Showing method of using sutures, in cases where this particular incision is made, and one or more teeth are absent.

Unusual Cases

1. Impacted canines which lie buccally. Usually in this type of impaction the tooth will be found above the apices of the teeth in position and directly below the antrum. Great care should be taken in the removal of these teeth to avoid penetrat-

ing the antral cavity. A good procedure is to remove the bone covering the inferior border of the tooth and work upwards.

2. Impacted canine, crown palatally, and apex so far buccally and encased in bone as to render its complete removal by way

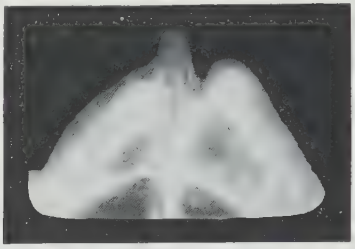


Fig. 166.—Bilateral impaction in edentulous mouth.

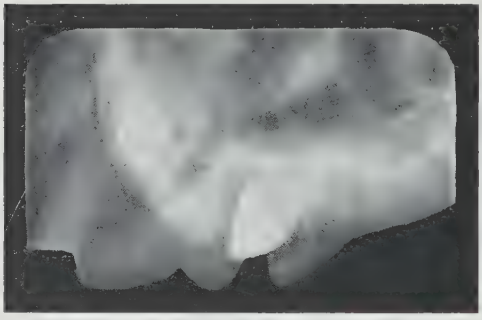


Fig. 167.—Bilateral impaction—edentulous mouth. These teeth are best removed palatally.

Fig. 168.

Figs. 168-172.—Types of impacted canines with crown portion palatally, which teeth however may be removed from the buccal aspect as well. This procedure is possible because of the absence of teeth in the adjacent areas. In removing these teeth from the buccal aspect, the root portion is exposed first, then by means of forceps the root is grasped, or an elevator is placed under the root portion and pressure is exerted outwards.

of the palate a dangerous procedure in so far as injuring the adjacent teeth is concerned. When this particular difficulty is encountered, it is best to remove as much of the tooth by way

Fig. 169.

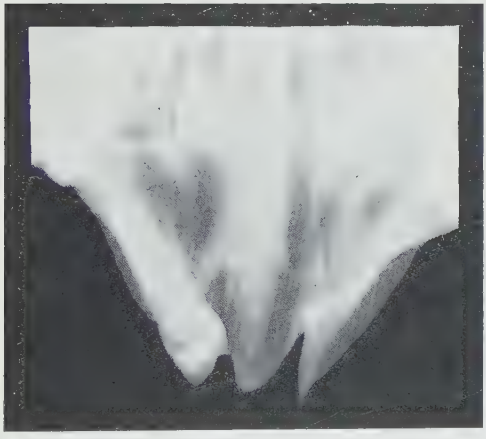


Fig. 170.

of the palate as is possible without causing injury to the adjacent teeth, or closing the palatal flap; then opening from the buccal aspect to remove the apical portion.

3. Impacted canines involved in dentigerous cysts. It is best in these cases to make a palatal incision, of the variety which

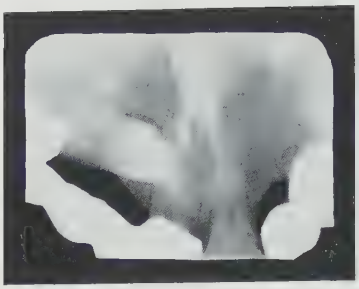


Fig. 171.

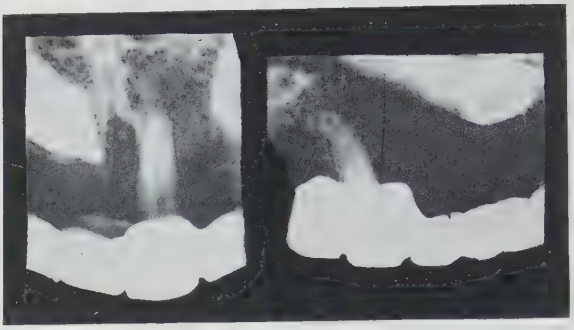


Fig. 172.

Fig. 173.—Radiogram of an impacted canine, which was removed, from the buccal aspect.

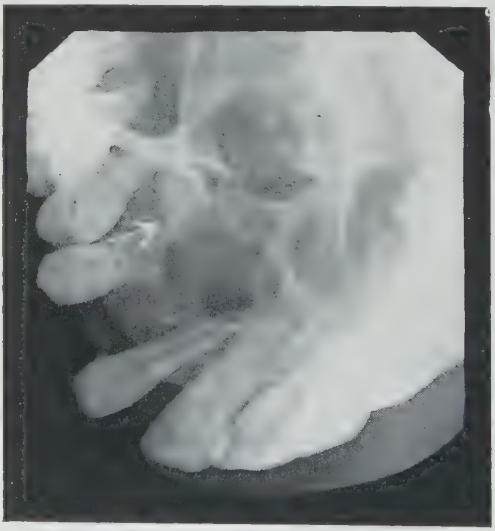


Fig. 174.—Radiogram of a case referred to the author after an unsuccessful attempt had been made to remove an impacted canine palatally. It will be noticed that the apex of the lateral incisor has been injured, and the apex of the canine is still in position. The apex was removed with little difficulty from the buccal aspect.

involves the gingival margins in order to get good access to the area.

4. Impacted canines situated palatally in the region of the first or second molar. It will be found that a semilunar incision, a quarter of an inch above the approximate position of the crown of the impacted tooth will give excellent results.

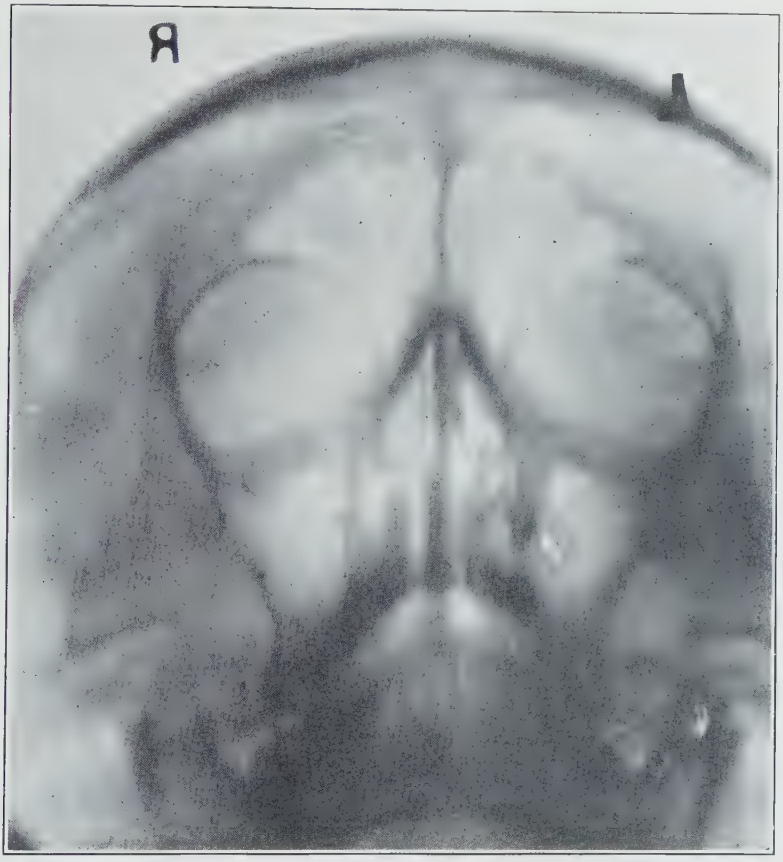


Fig. 175.—Case of a dentigerous cyst involving the antrum of Highmore, containing an impacted canine. This case was operated upon by way of the palate. Incision used was the one including the gingival margins of the teeth. The entire area was thoroughly cleared out. Patient made an uneventful recovery.

Illumination.—The best illumination is obtained with the use of the Cameron dental lamp. Precaution should be taken not to overheat. Owing to the fact that the palate is anesthetized the patient cannot feel the sensation of heat and a burn may cause sloughing of the flap. To obviate the probability of such

an occurrence the lamp should occasionally be immersed in sterile water to cool.

Postoperative Treatment and Complications.—The postoperative treatment is symptomatic. Patients are advised to return

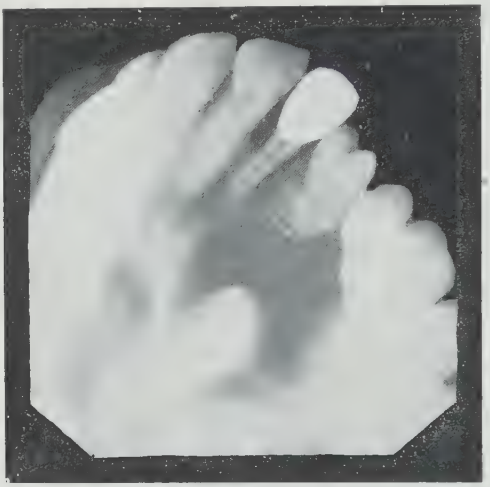


Fig. 176.—Impacted maxillary canine involved in dentigerous cyst, penetrating the maxillary sinus.

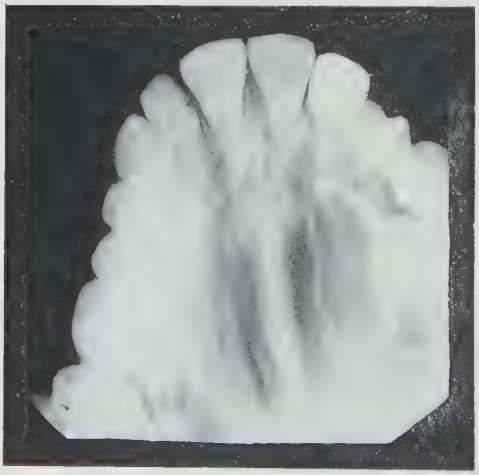


Fig. 177.

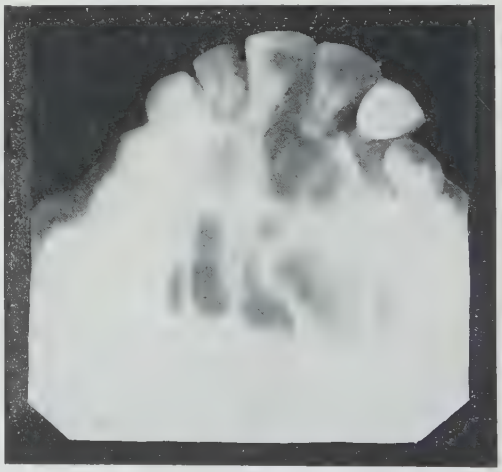


Fig. 178.

Figs. 177 and 178.—Same case six months later, showing bone regeneration.

the day following the operation and thereafter, at two and three-day intervals. They should never be discharged until the wound has completely healed.

Fig. 179.—Impacted maxillary canine penetrating the maxillary sinus.

Fig. 180.—Two weeks after operation.

Fig. 181.

Fig. 182.

Fig. 183.

Figs. 181-183.—Impacted canines situated in the posterior portion of the palate. A semilunar incision from above downwards involving the area of the tooth will afford the best means of access.

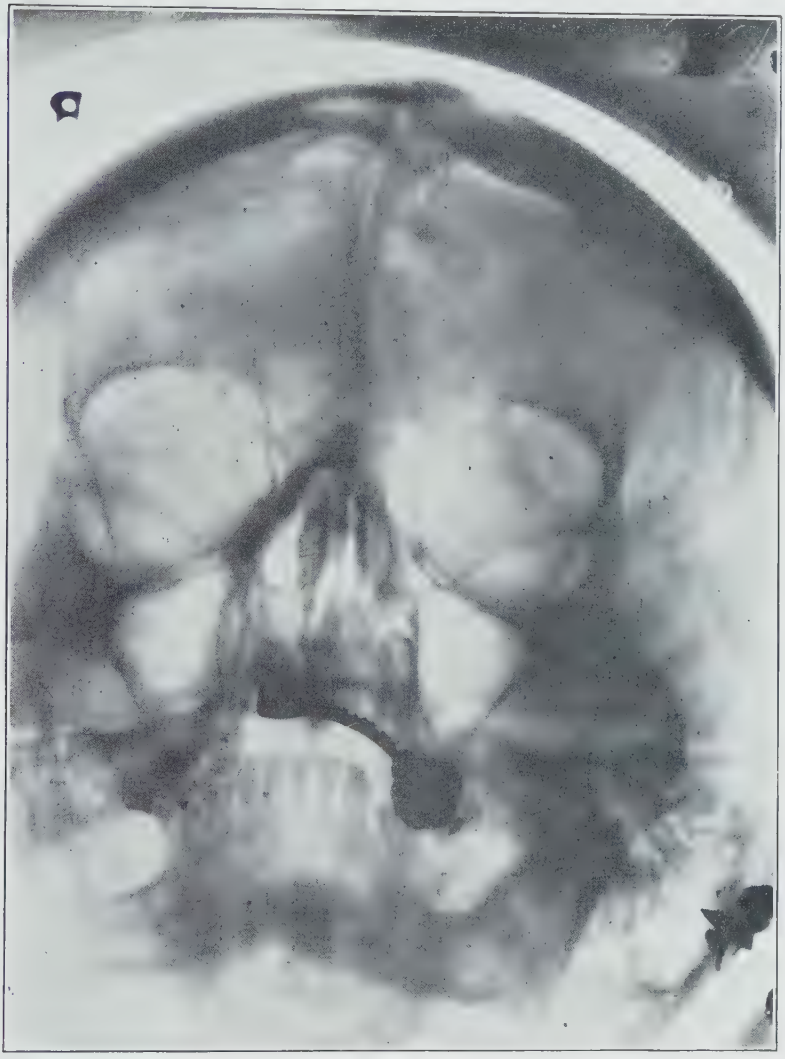


Fig. 184.—Impacted canine penetrating the nasal fossa. Tooth removed by means of the large palatal incision.

Postoperative Complications

A. Postoperative Edema.—Postoperative edema, following the buccal operation, is generally reduced by the application of cold compresses for twenty minutes of each hour.

Swelling of the palatal mucosa, following the palatal operation, occurs in some cases. This condition returns to normalcy in from three to four days.

In some instances, when the swelling has subsided, there may be a discharge of serum from an opening caused by lack of adhesion of tissues after the operation.

Daily irrigations with some mild antiseptic will bring about healthy union in a few days. In some cases, after the lapse of

Fig. 185.—Impacted maxillary canine beneath floor of orbit.

ten or twelve days there is a discharge of pus from the wound. This is usually evidence of a sequestrum. When these symptoms present themselves, the wound is reopened, the area curetted and all sharp edges of bone removed. The wound should then be irrigated every forty-eight hours until complete adhesion takes place.

Fig. 186.—Impacted canine crown partially exposed. These teeth are best removed by making an incision beginning at the mesial surface, including the gingival margin to the distal surface, and extending the incision posteriorly for half an inch. The bone is then removed from the posterior surface of the impacted tooth and force then exerted in that direction. The flap should then be brought back. One suture will be sufficient. The attempt to remove a tooth of this nature with a pair of forceps without any other surgical interference usually results in breaking off the crown portion.

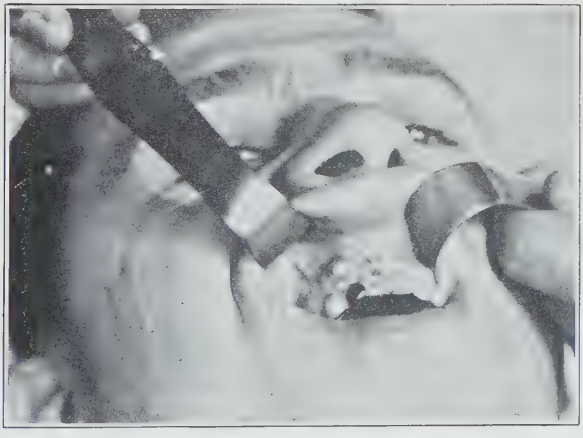


Fig. 187.—Impacted canine situated buccally. Incision should be made mesially, the gingival margin included. Flap retracted, overlying layer of bone removed until two-thirds of the tooth is exposed; tooth then lifted out, sharp edges of bone made smooth, and flap brought back and sutured.

B. Postoperative Hemorrhage.—Excessive bleeding may not necessarily be caused by the rupturing of a vessel. Very frequently a persistent capillary oozing occurs which will cause the patient distress. Patients should be instructed to press a gauze packing against the palate and to hold it in position by closing the jaws until bleeding ceases. If hemorrhage continues they should seek professional aid. Patients should be cautioned to continue biting gauze until other aid is obtained.

An excellent method of controlling hemorrhage is the use of gauze, one inch in length, saturated with suprarenin solution $\frac{1}{1000}$. Insert this into the wound between sutures. Pack and fill the wound over the suprarenin with borated or 5 per cent iodoform gauze strips for forty-eight hours. The gauze should not extend beyond the lips of the wound for two reasons:

1. It may be loosened during mastication.

2. Gauze between the lips of a wound may cause the mucous membrane to become smooth. This may prevent the natural process of healing.

C. Postoperative Pain.—Patients seldom complain of severe postoperative pain. As a preventive and corrective, pyramidon, one 5-grain tablet, taken every three hours, is recommended.

When the temporary inhibition of the conductivity of the sensory nerve endings has worn off and the normal sensation returns, it has been found that the amount of postoperative pain bears no relation to the form of injection used.

It is the same if the injection has been made directly in the nerve terminals (terminal or infiltration anesthesia) or by acting on the nerve trunks supplying the site of operation, thereby interrupting the conduction of sensory impulses (regional or conduction anesthesia). It should be borne in mind that postoperative pain is caused by the trauma sustained in the operation and that the anesthetic agent plays no part except that its nerve-stilling effects are gradually lost and the true situation—pain from the operation—evidences itself. Therefore, the more careful we are in the retraction of tissues and the cleaning up of all sharp edges and points following an operation, the more grateful our patient will be as subsequent experiences will demonstrate.

CHAPTER XX

IMPACTED MAXILLARY PREMOLARS

Impacted maxillary premolars are generally situated with the crown palatally. As a general rule this type of impaction offers very little difficulty in removal. When the small No. 1 radio-

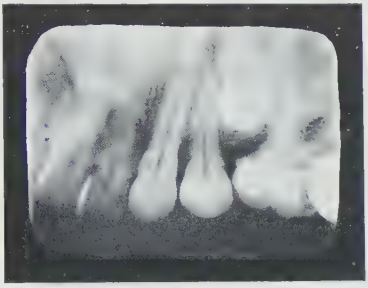


Fig. 188.—Impacted maxillary second bicuspid situated palatally.

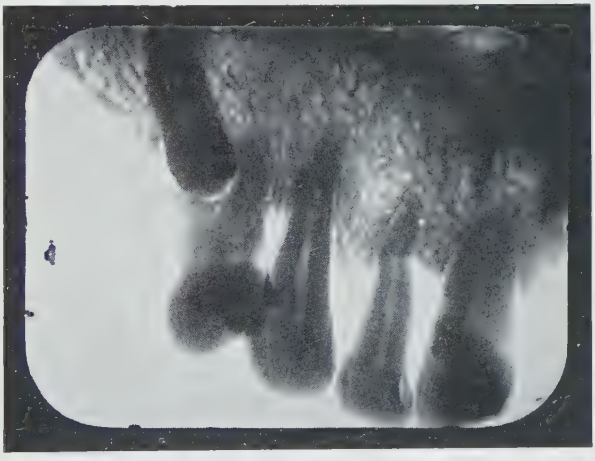


Fig. 189.—Impacted maxillary second bicuspid.

gram indicates that the crown of the tooth is close to the gingival margin, a vertical incision on the palate mesially to the tooth and extending about an inch is made; thereupon with a broad periosteal elevator, the soft tissues are retracted (the gingival margin of the tooth in position in the arch being in-

cluded) and held aside, either with the periosteal elevator or by passing a horsehair ligature through the flap, tied to one of the molars. The overlying bone covering the crown portion of the impacted tooth is removed, an elevator is inserted under the

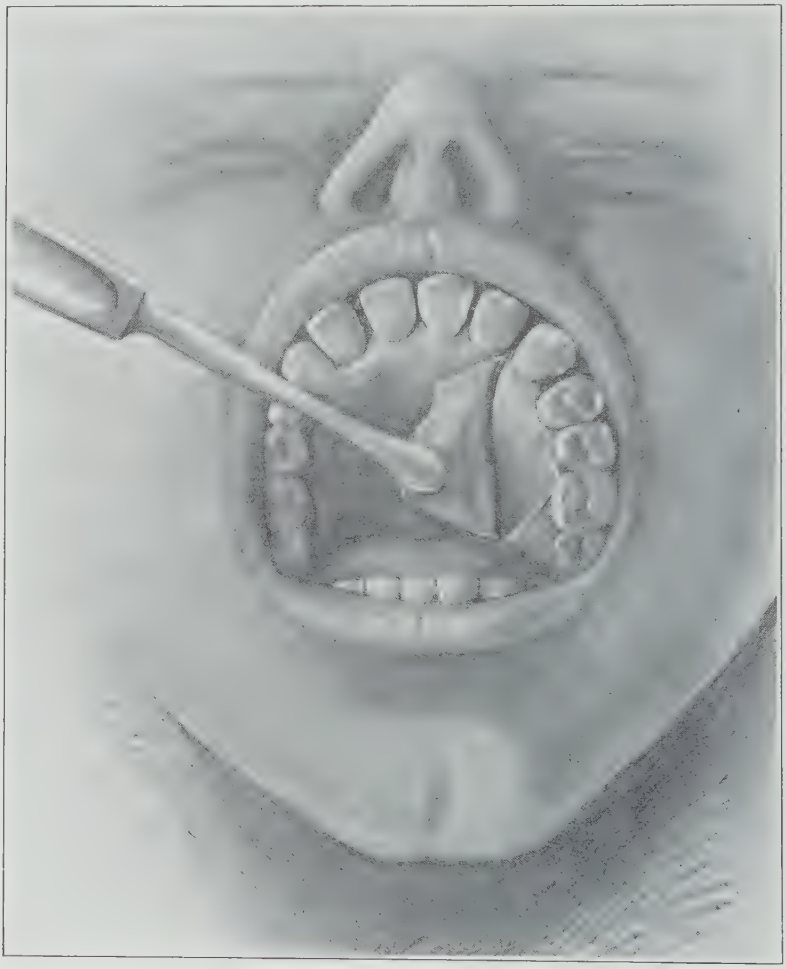


Fig. 190.—Nature of incision for the removal of an impacted tooth situated palatally, the crown lying close to the gingival margin in the bicuspid area.

crown and the tooth is dislodged. The wound should then be thoroughly cleansed, and the flap brought back and sutured.

Impacted maxillary premolars which, upon radiographic findings, show the crown to be a distance from the gingival margins, should be removed by making a semilunar or semicircular inci-

sion a safe distance from the gingival margin to insure the life of the flap after suturing. If in these cases the incision is made too close to the gingival margin, the portion of mucous mem-

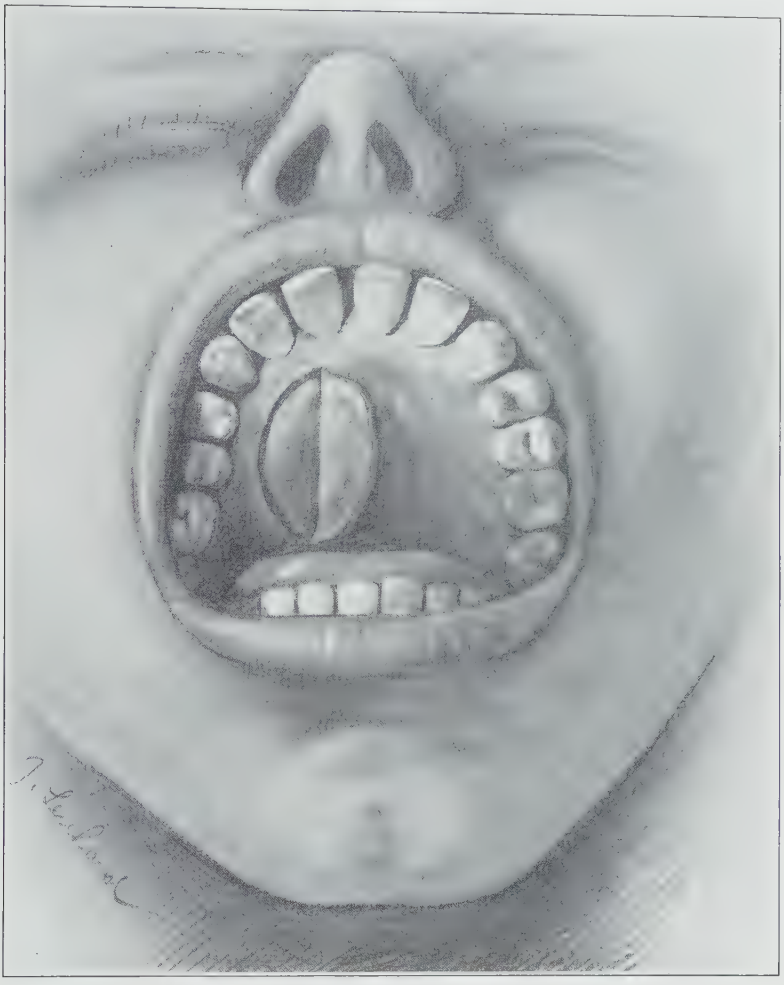


Fig. 191.—Nature of incision for impacted tooth situated palatally in the bicuspid region with the crown portion a distance from the gingival margin.

brane at the gingival line is apt to be torn or mutilated in the attempt to pass a suture through it. In cases where the margin is not torn, the flap will very likely slough away, due to the lack of a sufficient blood supply in so narrow a strip.

CHAPTER XXI

IMPACTED MAXILLARY FIRST AND SECOND MOLARS

Impacted maxillary first and second molars should always be removed from the buccal aspect. A vertical incision mesially to the impacted tooth is made and the soft structures, inclusive of those of the adjacent tooth, are retracted; the overlying bone

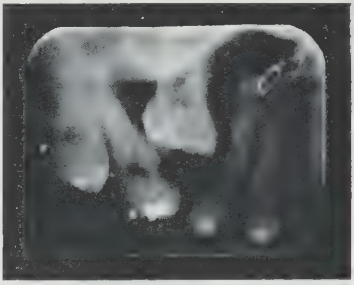


Fig. 192.—Impacted maxillary first molar. This type of impaction is best removed from the buccal aspect. An incision should be made mesially from the gingival margin upward, the soft structures retracted, and two-thirds of the tooth exposed before attempting to remove it.

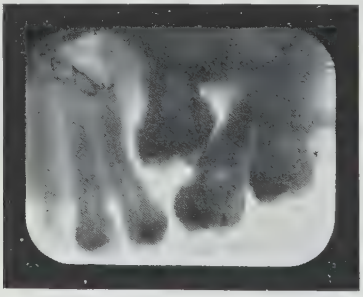


Fig. 193.—Impacted maxillary first molar, crown situated palatally.

is removed with mastoid gouges, chisels, and surgical burs; the tooth is luxated and the flap brought back and sutured. Care must be taken to have the soft tissues sufficiently retracted so as to have a complete view of all the overlying bone which is to be removed, as the indiscriminate use of a bur or chisel for the removal of bone situated under the flap may result in an accidental opening into the maxillary sinus.

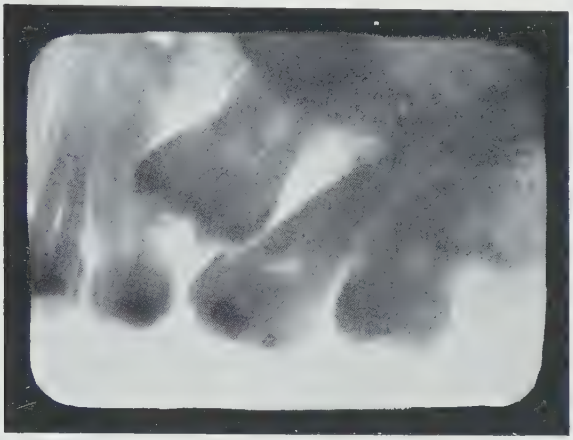


Fig. 194.—Impacted maxillary first molar situated palatally.

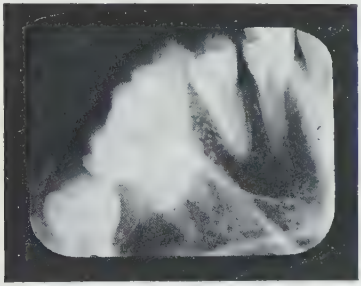


Fig. 195.—Impacted maxillary second and third molars. Incision for the removal of these teeth should be made mesially to the second molar and posteriorly along the ridge inclusive of distal surface of third molar.

CHAPTER XXII

GENERAL PRINCIPLES IN THE OPERATION FOR AN IMPACTED MAXILLARY THIRD MOLAR

To avoid serious accidents, such as forcing the tooth into the antrum of Highmore, no attempt should be made to force a pair of forceps over the crown of the impacted tooth, even though a portion of the crown is exposed, unless the soft tissues are sufficiently retracted to make it possible to observe with just what portion of the crown the beaks of the forceps come into contact. Placing a pair of forceps on the portion of the crown which is exposed and shoving up to obtain a better hold without observing the nature of the obstruction, will result in forcing the tooth into the antrum. The beaks of the forceps striking an extra cusp may force the tooth upwards and thus fail of their purpose to grasp the crown. Several cases of the above nature have come to my attention.

Technic for the Removal of Impacted Maxillary Third Molars

Impacted maxillary third molars occupy many and varied positions. Radiograms act as an important guide in planning our operation, but cannot, however, always be relied upon. Impacted third molars, which from the radiogram would appear to present operative difficulties, are very often found to be easily removable. On the other hand, the impacted third molars which the radiogram seems to indicate are easy of removal often offer considerable difficulty. Radiograms should be carefully studied and the operation equally carefully planned. We must, however, be prepared to alter our technic when, upon the retraction of the soft tissues, it is found that we have erred in the correct interpretation of the picture.

A very important procedure is the careful examination of the supporting structures of the adjacent tooth. The following is an important case in point:

The patient, a woman, was referred to me for the removal of an impacted maxillary third molar. The radiogram revealed the

presence of an impacted upper third molar, the crown of which, to a large extent, had been destroyed by caries. A second molar was in position, but there were no other teeth on that side. The patient was wearing an artificial denture, one clasp of which fitted around this molar. She was extremely anxious to retain this tooth, for its loss would necessitate her wearing a full denture, as the removal of this tooth would mean the loss of anchorage for the plate on that side, in which event it would then be best to extract the teeth of the opposing side. The patient inquired whether it would be necessary to extract the second

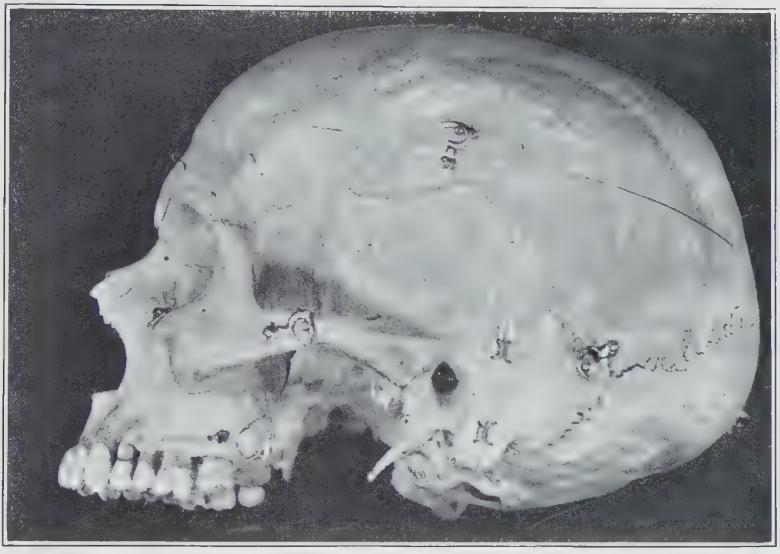


Fig. 196.—Dry specimen showing impacted maxillary third molar. Note cancellous structure of bone directly adjacent to the tooth. The nature of this bone will readily yield to the force exerted upon a spear-pointed elevator, either by the aid of hand or mallet force.

molar, in order to remove the third molar, to which the answer was in the negative. While the answer was correct for the normal case, it was given without examining the condition of the second molar. An incision was made and in retracting the soft structures with a blunt periosteal elevator, happening to touch the second molar it was found to be so loose as to cause wonderment as to how it ever stayed in her mouth. These findings were communicated to the patient with the explanation that though the impacted tooth could be removed without removing the second molar, it would be but a few days following the

Fig. 197.—Impacted maxillary third molar, edentulous mouth.

Fig. 198.—Incision for impacted maxillary third molar, edentulous mouth. Incision should be made directly to the bone, cutting through mucous membrane and periosteum.

operation when the tooth would drop out of its own accord, since the impacted tooth was acting as a wall at the distal surface of the second molar and the removal of this wall would be fatal to the second molar. It was explained to her that while

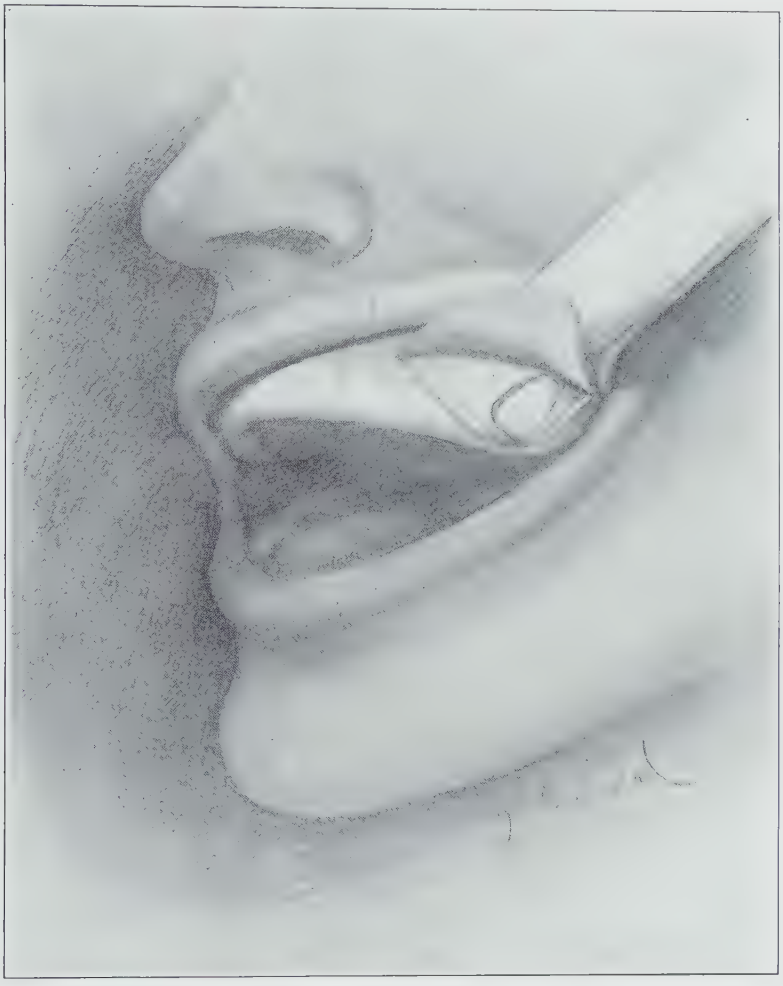


Fig. 199.—Elevation of the mucous membrane and periosteum and with two-thirds of the overlying bone removed. When the tooth is exposed to this extent, a spear-pointed elevator may be inserted mesially or distally and the tooth luxated out of its socket.

her jaw was anesthetized it might be best to remove the second molar. The patient reluctantly agreed to this; however, the impression might readily have arisen that a misrepresentation had been made.

All impacted maxillary third molars should be removed from the buccal aspect. They are divisible into two main groups:

1. Impacted maxillary third molars in an edentulous area.
2. Impacted maxillary third molars—adjacent teeth in arch.

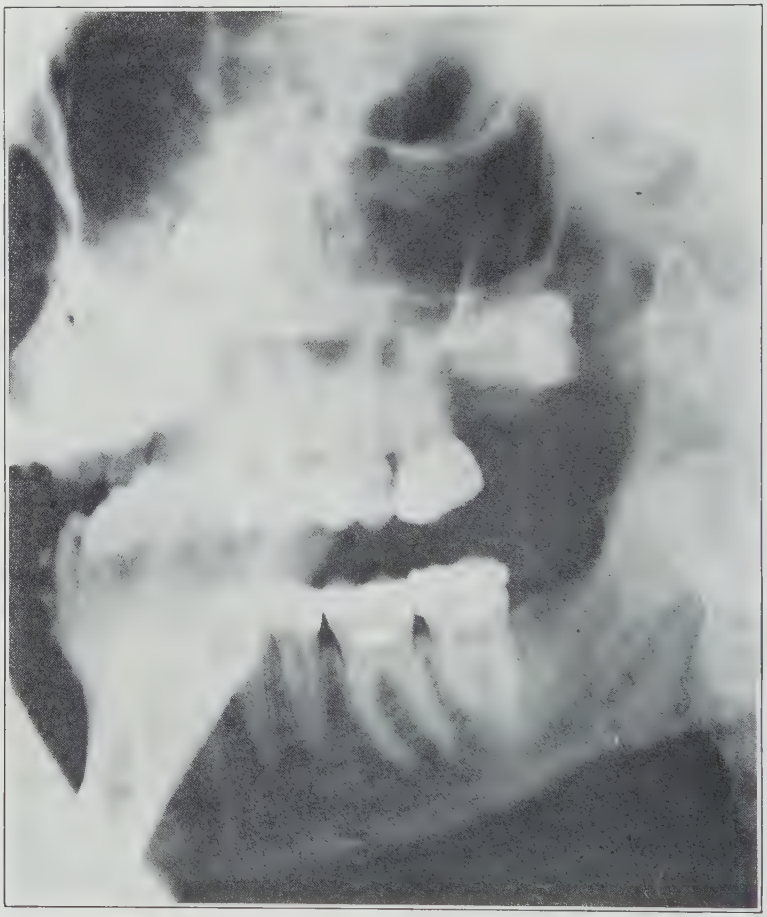


Fig. 200.—Impacted maxillary third molar lying horizontally, crown distally.

Impacted Maxillary Third Molar—Edentulous Mouth

A vertical incision is made in the region of the first molar and carried posteriorly through the center of the ridge to its posterior margin; the soft tissues are retracted, the overlying bone is removed, the tooth is extracted with a forceps or by means of an elevator, the sharp edges of the bone are made smooth, and

the wound is irrigated and sutured. The soft tissues are then brought back into position and sutured. Care must be taken to approximate the lips of the wound and not have them overlap.

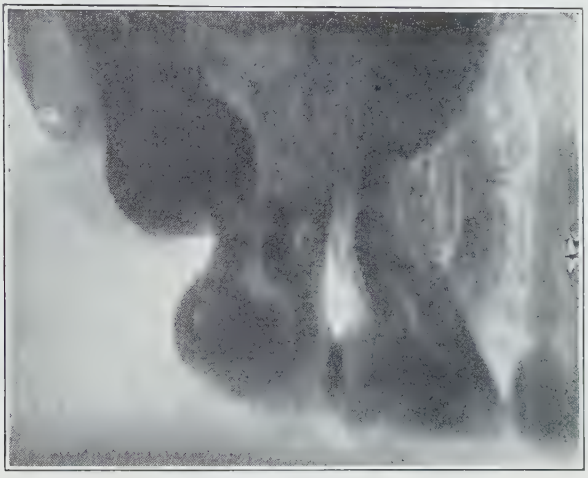


Fig. 201.—Impacted maxillary third molar.

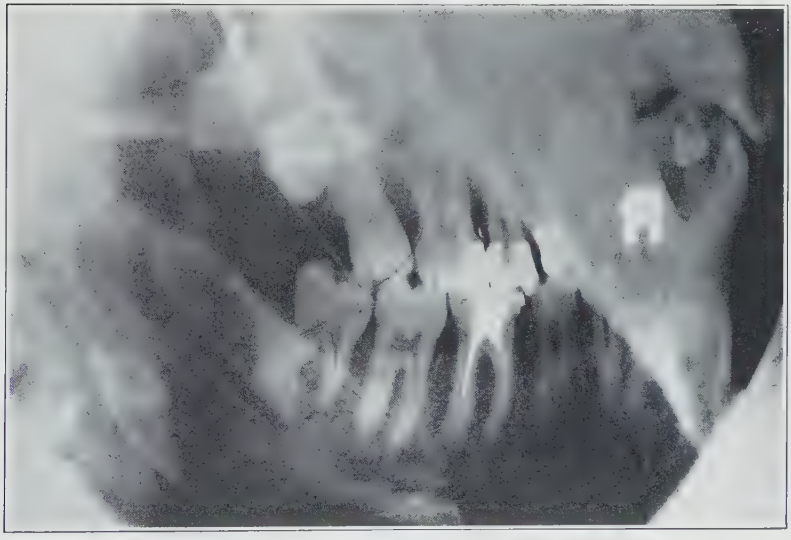


Fig. 202.—Impacted maxillary third molar, crown situated distally.

A dressing may be inserted into the wound between the sutures for forty-eight hours. The sutures should be permitted to remain for eight or ten days.

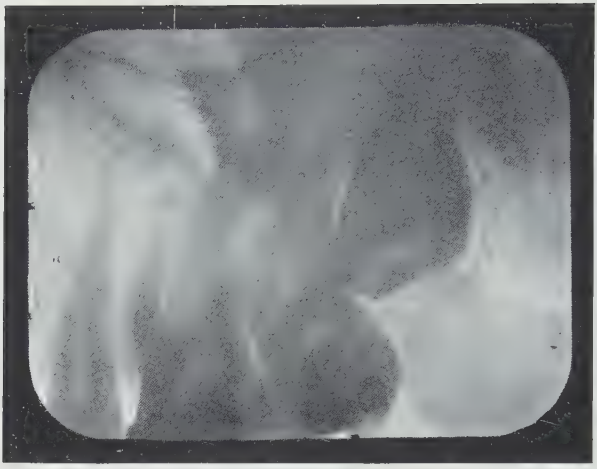


Fig. 203.—Impacted maxillary third molar.

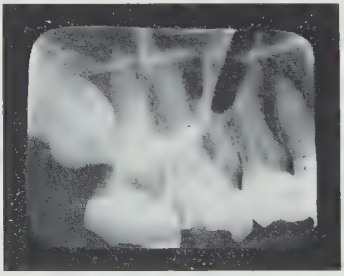


Fig. 204.—Impacted maxillary third molar.

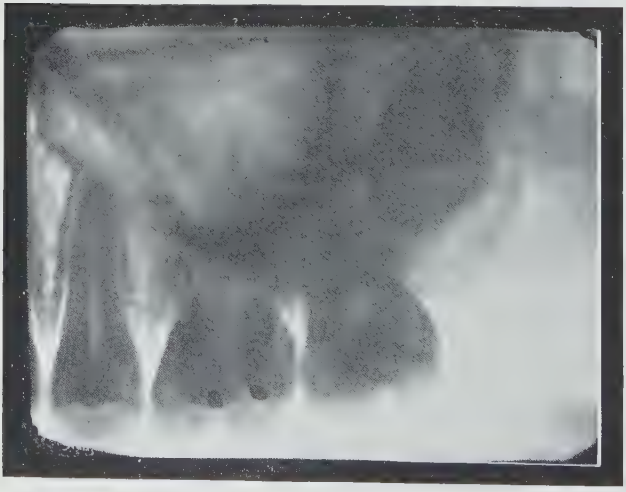


Fig. 205.—Impacted maxillary third molar situated unusually high.

Care must be taken not to exert too great force in using the outer plate as a fulcrum, otherwise a fracture of the tuberosity may result.

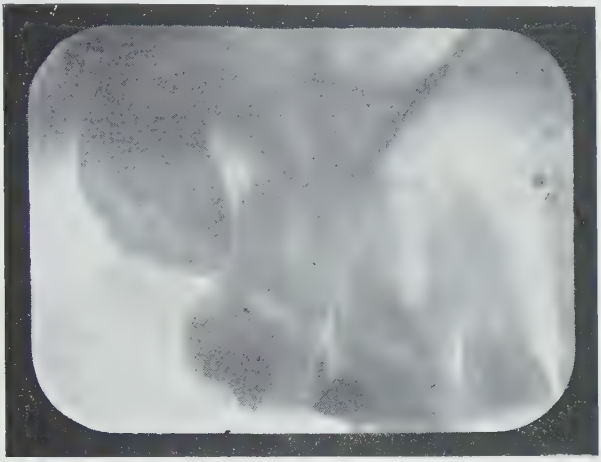


Fig. 206.—Impacted maxillary third molar, showing destruction of bone mesially; in this type of impaction after soft structures are retracted, a spear-pointed elevator may be inserted in this space, the bone used as a fulcrum, and the tooth luxated.

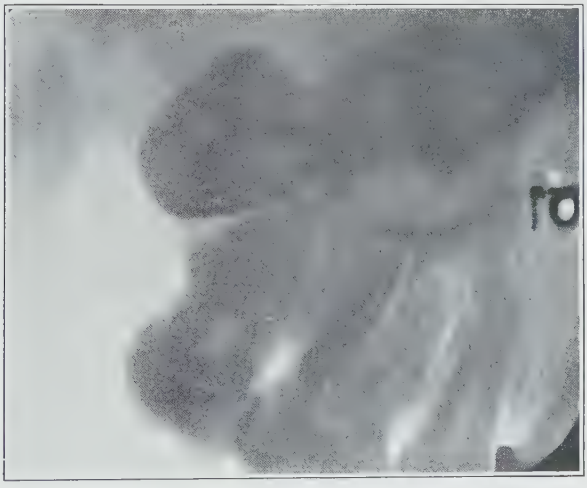


Fig. 207.—Impacted maxillary third molar situated unusually high.

Impacted Maxillary Third Molar—Adjacent Teeth in Arch

These teeth when impacted should always be removed from the buccal aspect. The exceptions to this rule will be taken up subsequently. It matters very little as to the position which the

impacted tooth occupies. That is to say, in some cases the crown may point distally, and at right angles to the second molar. The point remains that the tooth must be exposed, and the best means of doing this is to insure a good view by making a proper flap. When the overlying bone is exposed, it should be removed surgically, and not be bitten off by means of tooth forceps. No attempt to dislodge the tooth should be made until

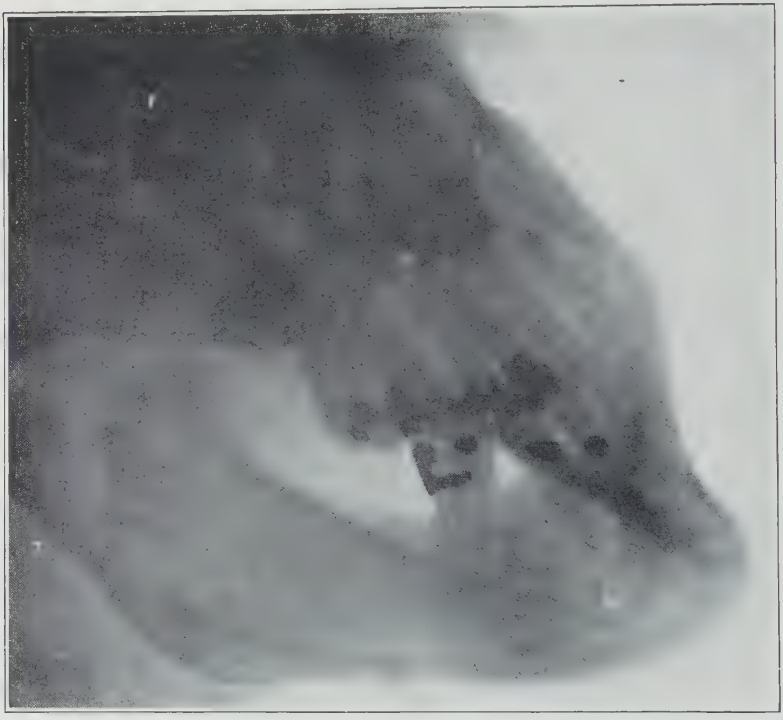


Fig. 208.—Impacted maxillary third molar, the crown of which was carious, showing that food and débris can seep along distal root of second molar and cause a carious condition, even though the tooth is completely covered by gum.

the crown is completely exposed. When the crown has been exposed, through the removal of the overlying bone by means of gouges, chisels, or surgical burs, an attempt may be made to insert a spear-pointed elevator into a space between the crown of the impacted tooth and the alveolar process, with the maxilla —not the adjacent tooth—as a fulcrum, and the attempt made to luxate it. In cases where the crown of the impacted tooth is carious and where any force exerted upon it causes it to break

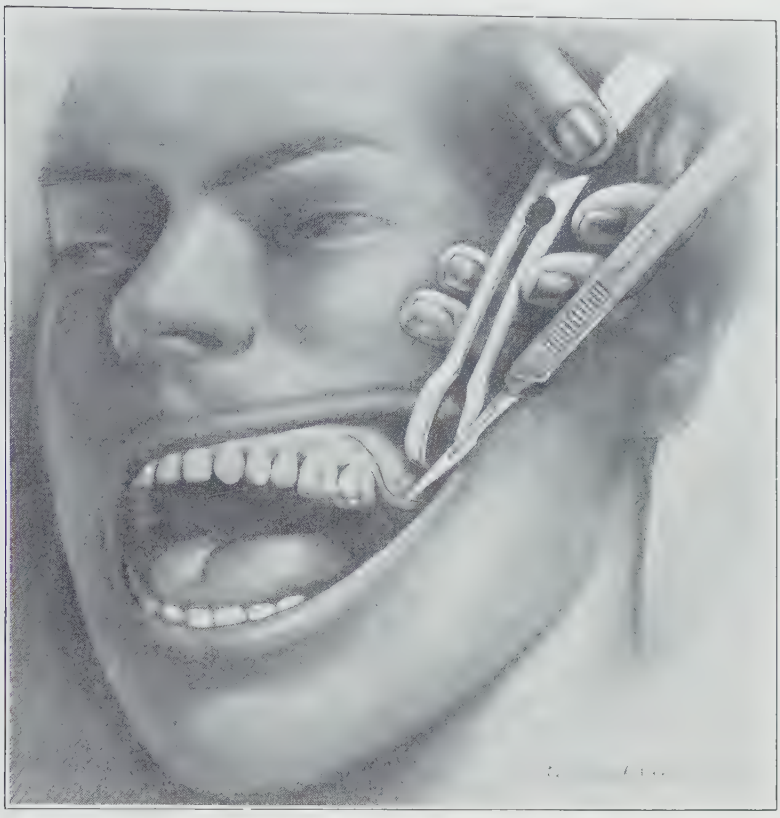


Fig. 209.—Incision for completely impacted maxillary third molar. Note the avoidance of the gingival margin of the second molar.

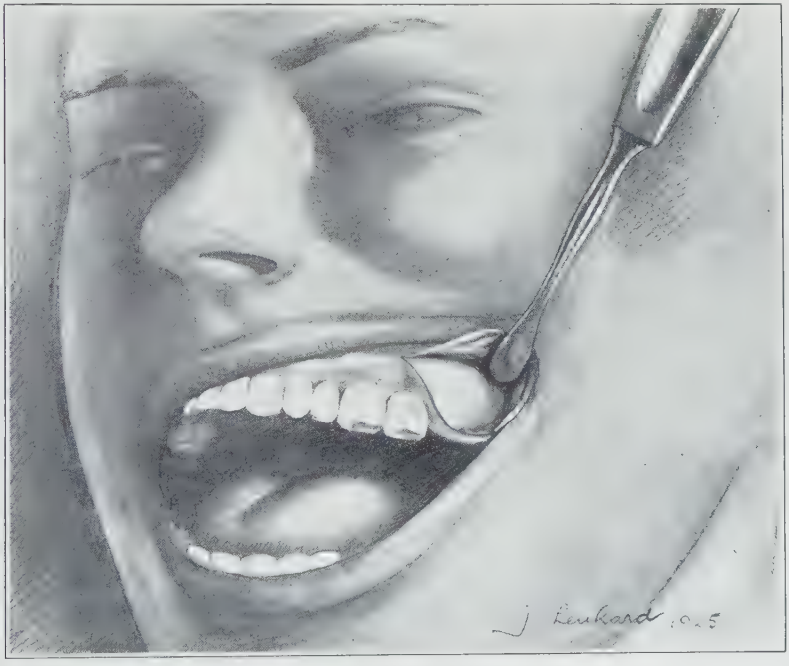


Fig. 210.—Elevation of the mucoperiosteal flap. Note broad, blunt periosteal elevator.

Fig. 211.—The position of the gouge or chisel for the removal of the external layer of bone covering the impacted tooth.

off, the portion of bone covering the mesial surface of the root portion should be removed, and the spear-pointed elevator inserted between the root portion and the maxilla and pressure exerted in an outward direction.

Very few radiograms show the root formation of the impacted third molar. The roots may be fused into one, may be bifurcated, or branch out into four or five. They may be curved and tortuous. Undue force exerted in these cases may result in frac-

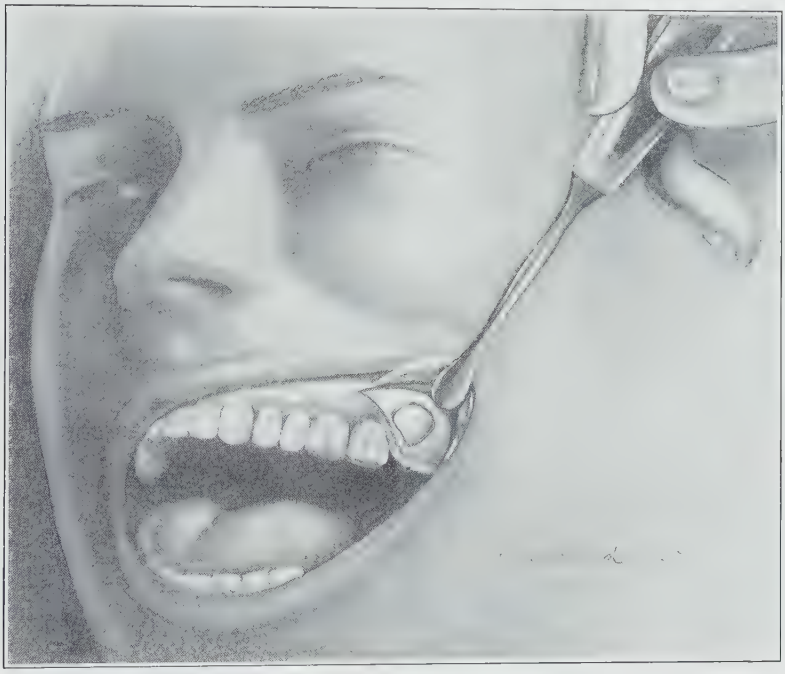


Fig. 212.—Showing sufficient bone removed to permit of the insertion of an elevator.

ture of the tooth, a portion of a very thin root apex remaining, the removal of which, due to its inaccessibility, may result in needless injury and traumatization of the tissues, with the possibility of forcing the root into the maxillary sinus. When resistance is encountered in the attempt to dislodge the impacted tooth, the area should be cleared of blood (in so far as this is possible), the tissues retracted, and an endeavor made to ascertain the particular obstruction, and how to remove it. It is better to remove more bone than to break off the crown, since

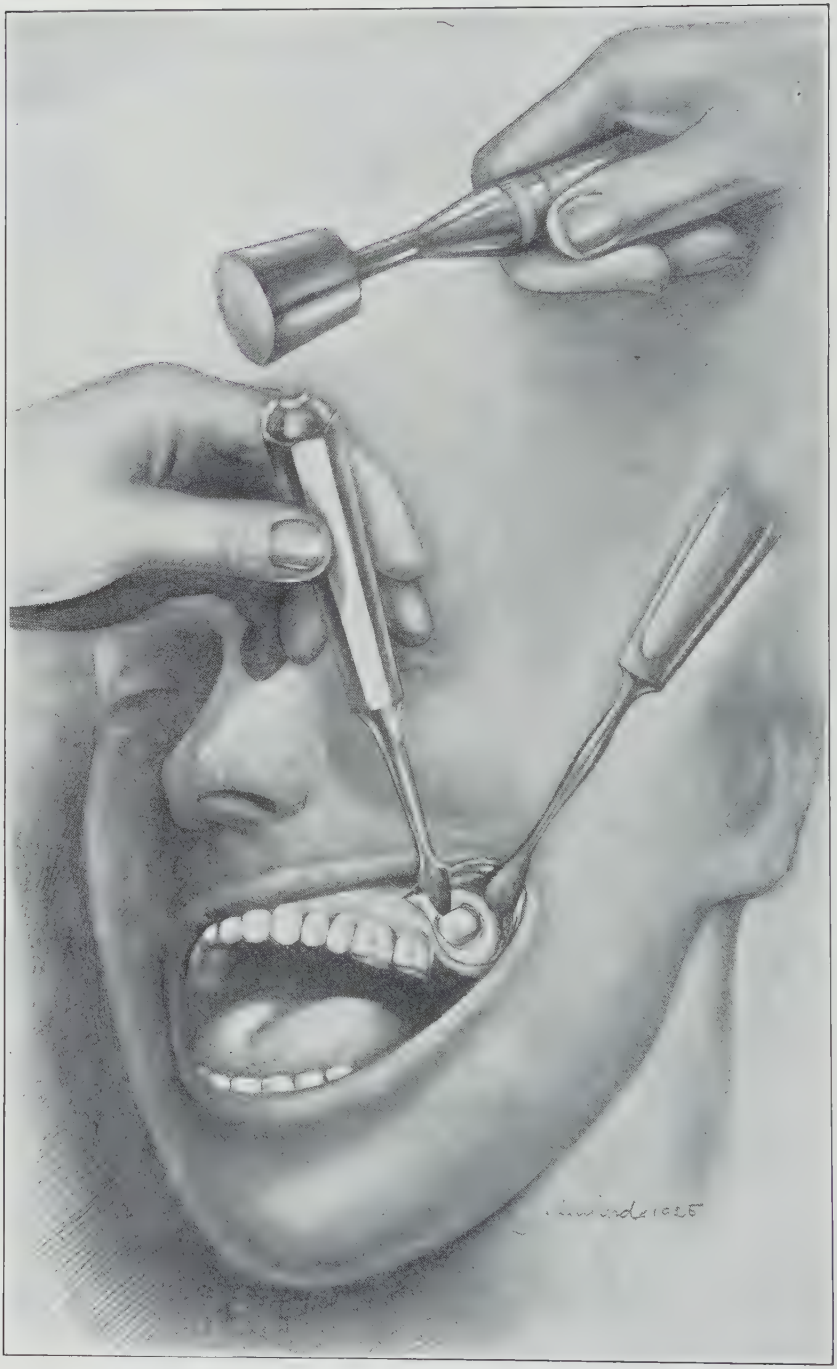


Fig. 213.—Position of the spear-pointed elevator on the mesial surface of the impacted tooth.

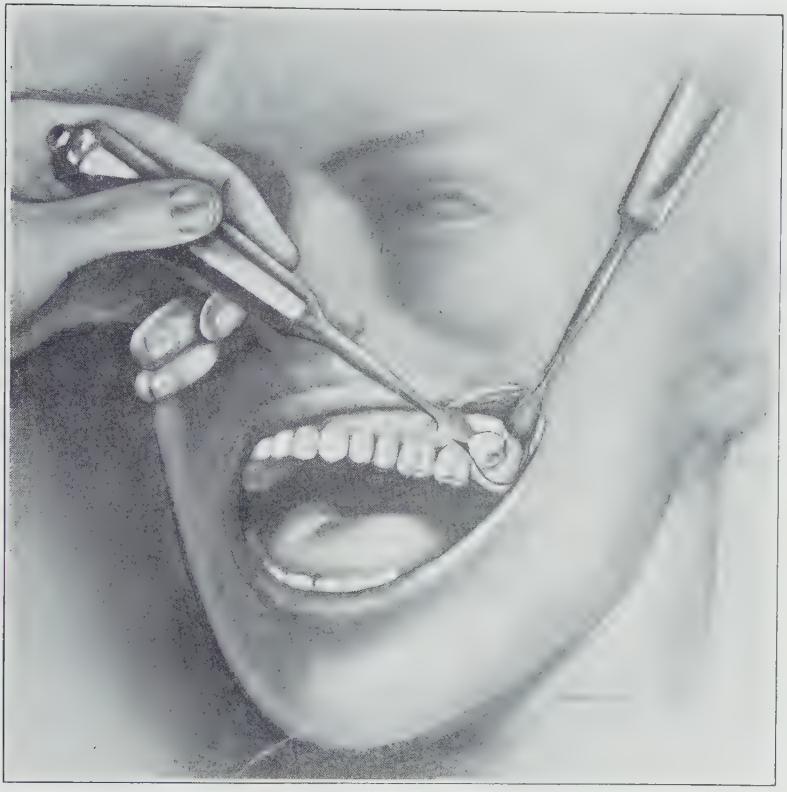


Fig. 214.—Showing use of the jaw, not the adjacent tooth, as a fulcrum for the elevation of the impacted tooth.

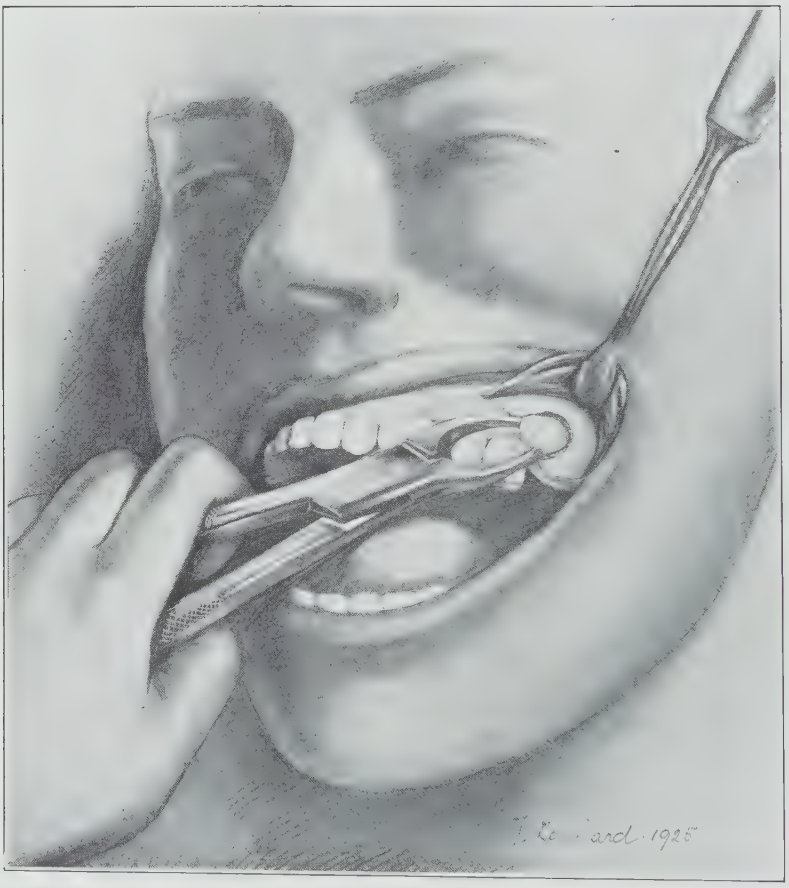


Fig. 215.—The grasping of the tooth by the aid of forceps. The tooth should not be completely dislodged by the aid of the elevator, for in so doing it may become dislodged in the patient's mouth.

when the latter situation arises the outline of the tooth is lost, and subsequently difficulty is experienced in removing the roots. After the removal of the tooth, the wound should be carefully irrigated with a mild antiseptic solution, all roughened surfaces of bone made smooth, a dressing of 5 per cent iodoform gauze inserted, and the flap brought back into position. If it remains

Fig. 216.—Showing flap sutured in position following removal of impacted maxillary third molar.

in position, no suture is necessary; if not, one should be inserted. The dressing should be packed fairly tight, to control bleeding, and also to prevent infection. The dressing should be permitted to remain for forty-eight hours, when repacking will be found unnecessary. Irrigation should be continued until the wound has sufficiently filled in to admit of the parts being reached by the use of a mouth wash, applied in the usual manner.

When the radiogram discloses the tooth lying directly posterior to the second molar with the crown midway between the

buccal and the lingual plates of bone, or more toward the lingual, the incision should be carried to the lingual border and, after exposing the crown, the tooth should be removed by means

Fig. 217.—Maxillary third molar forced into the antrum of Highmore.

of a pair of forceps placed in position around the crown of the tooth.

Impacted Maxillary Fourth Molars

These teeth, when impacted, are generally of the rudimentary type. The technic for their removal is analogous to that for the impacted maxillary third molar.

Fig. 218.—Impacted maxillary third and fourth molars.

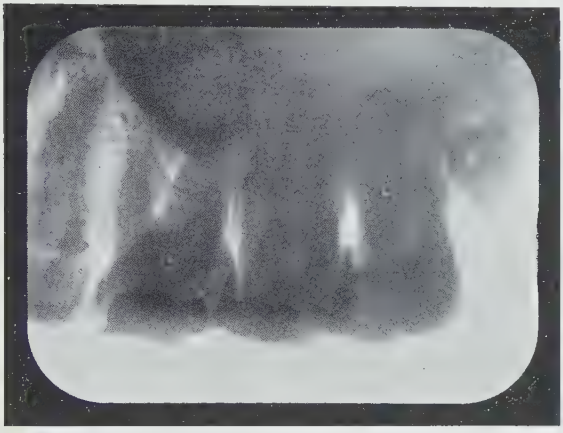


Fig. 219.—Impacted maxillary fourth molar.

Impacted Mandibular Incisors

These teeth when impacted are usually associated with the impacted canines. When impacted individually, the technic for their removal is analogous to that for the mandibular canines, outlined in a succeeding chapter.

CHAPTER XXIII

IMPACTED MANDIBULAR CANINES, PREMOLARS, FIRST AND SECOND MOLARS

Impacted canines of the mandible are divisible into two main groups:

1. The vertical impaction; 2. the horizontal impaction. In many cases we find these impactions involved in dentigerous cysts. Impacted canines in the mandible generally assume a horizontal position under the bicuspid teeth. In practically all instances of this nature, the impacted tooth may be removed without disturbing the apices of the teeth in the arch, situated in this region.

The technic in a case such as described would be to make a semilunar or semicircular incision, midway between the gingival margin and the apices, extending over the bicuspids and the first molar. The mucoperiosteal flap is then turned downward and held aside by the left hand and a portion of bone is removed a safe distance from the apices of the bicuspids, and the tooth definitely located, after which more of the bone is removed in a horizontal plane, until a sufficient amount of the tooth is exposed to permit of its removal. Care should be taken not to enter the mental foramen.

After the tooth has been removed, all rough surfaces of bone should be made smooth and the wound should be irrigated and then sutured. Unless there is profuse bleeding or a persistent capillary ooze, packing of the wound is not necessary after the lapse of forty-eight hours. The wound should be irrigated daily until complete healing has taken place. In such cases, the question may arise as to the advisability of removing a tooth which shows no evidence of bone pathology in so far as radiographic findings indicate, and has given the patient no discomfort. Our answer is that clinical experience has proved to us that in many cases of impacted teeth where there was a total absence of bone pathology in the radiogram, the removal of the impacted tooth afforded no relief of the indicated nature.

Fig. 220.—Impacted mandibular lateral incisor, canine, and first bicuspid. When multiple impactions present themselves on the same side of the jaw, they are best removed in one operation.

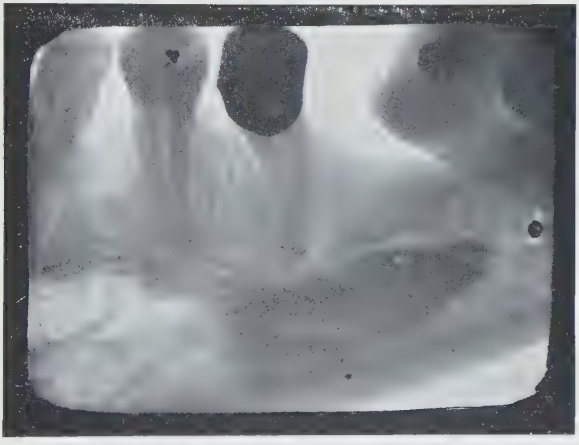


Fig. 221.—Impacted mandibular canine lying horizontally.

In case of no systemic involvement the decision as to the removal of such an impacted tooth rests entirely with the individual. On being apprised of the existence of such a condition, some patients will inquire as to approximately how long the

abnormality has existed, and upon being informed will make the comment that since it has been there for so protracted a period without giving trouble, there is no reason why it cannot be permitted to remain in situ until it becomes a disturbing element. Again we have the type of patient who, upon being informed of the presence of a tooth of this nature, will insist upon its

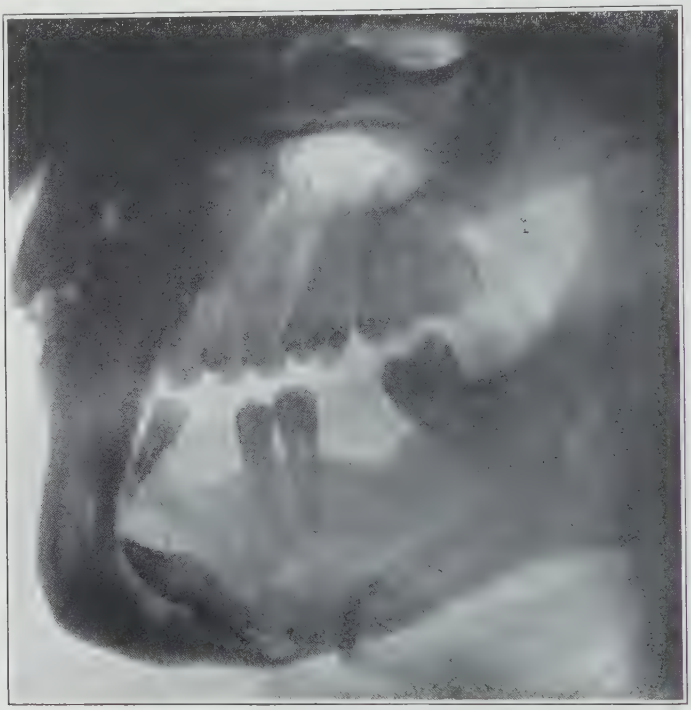


Fig. 222.—Deeply impacted mandibular canine.

removal because of having heard of this or that person becoming blind or insane from the retention of an impacted tooth.

The cures are at times difficult to explain. Recently a patient, referred to me for the removal of an impacted canine in the mandible, desired this tooth removed, declaring that she had been troubled with insomnia for twelve years, that all tests had been made and found negative, and that it was her opinion that the trouble must necessarily lie in the jaw. After the removal of the tooth she asseverated that she slept perfectly well, even immediately after the operation, without the necessity of resort-

ing to sleeping potions. The impacted tooth may have been a factor in her systemic disturbance; however, it seems more likely that the patient, after repeated examinations and tests, was advised that there remained but the elimination of one more

Fig. 223.—Lateral plate of mandible showing deeply impacted mandibular canine.

factor and this having been accomplished, she decided that she required no further medication. The border line between psychologic and drug effect is frequently difficult of determination, and the above is a case in point.

A careful study of the radiograms will show the necessity, at

Fig. 224.—Bite film showing deeply impacted mandibular canine in cross section.

Fig. 225.—Radiogram taken immediately following removal of tooth.

certain times, of deviating from the usual procedure of first exposing the portion of the largest diameter in the operation for the removal of an impacted tooth. Figs. 223, 224 and 225 illustrate a case where the removal of the bone overlying the crown may have resulted in a considerable loss of bone. In this case, an incision, as previously described, was made, the overlying tissues were retracted and about two-thirds of the tooth, from apex downward, was exposed. A spear-pointed elevator was then passed under the apical portion and the latter was lifted free from its attachment; then by means of a pair of thin beaked upper forceps, the tooth was rotated out of its socket with a minimum destruction of bone.

Fig. 225 is a radiogram taken immediately following the operation. In cases of impacted mandibular canines where there are no overlying teeth, an incision along the ridge and then turning the entire flap downward, will be found to be the most convenient procedure.

Impacted mandibular canines occupying a vertical position may be best removed by making a vertical incision mesially to the tooth extending from the ridge to the apex, retracting the tissues and exposing approximately two-thirds of the tooth, when it will be found that the tooth will offer little, if any, resistance to removal.

The attempt to remove an impacted tooth when but a small portion of the crown is exposed will generally result in its fracture. It must be remembered that the bone overlying it is hard, solid, and compact and cannot be broken with a pair of tooth forceps without danger of fracturing the mandible.

The postoperative treatment consists of placing a dressing into the wound. In cases in which the coagulation and bleeding time tests are below normal, the dressing should be packed in tightly and kept in position for forty-eight hours. When the coagulation and bleeding time tests are normal, a dressing impregnated with some dusting powder may be used to control postoperative pain. In cases in which there has been but little trauma, and the coagulation and bleeding time are normal, the dressing may be omitted. In cases in which after the lapse of two or three weeks, there is evidence of a granuloma or of an exuberant growth of granulation tissue, the area should be in-

filtrated with 1 per cent novocaine solution and the neoplasm should be removed.

When a curettage of this nature is indicated, the wound should be packed for twenty-four hours subsequent to the operation, and frequent irrigations employed until complete union has taken place.

Impacted Mandibular Canines with Cystic Involvement

In cases where the impacted mandibular canine is involved in a follicular or dentigerous cyst, careful digital palpation will determine the nature of the incision which is to be made, since

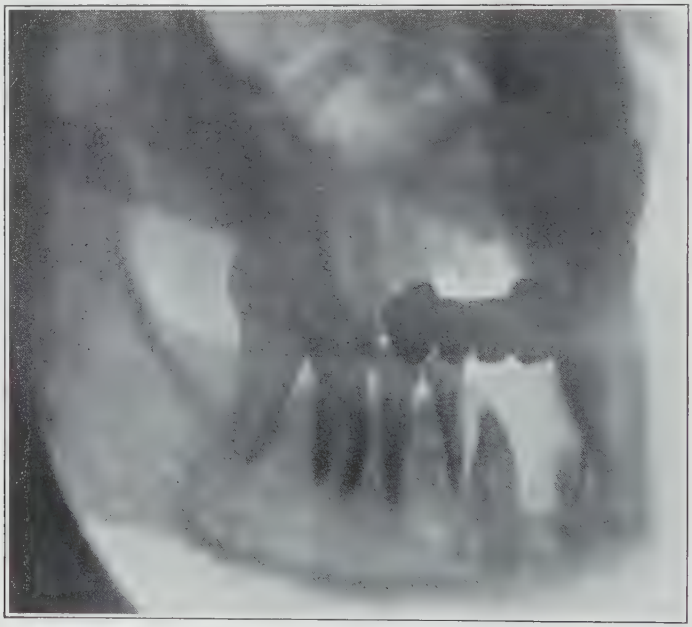


Fig. 226.—Impacted mandibular lateral and canine in vertical position, embodied in a dentigerous cyst. Incision should be made mesially or anteriorly.

it is just as important to remove the entire cystic membrane as it is to remove the impacted tooth. If the incision is improperly made, the cystic membrane may be pierced by the knife, and its definite outline thus become lost; considerable difficulty in its thorough or complete removal is thereupon experienced.

For the purpose of a guide in our operative procedure, we divide the dentigerous or follicular cysts into three classes:

1. Evidence of fluctuation upon digital palpation.

2. Evidence by digital palpation of a wet cardboard-like consistency of the bone which may be compressed, but will resume its position like a spring.

3. Hard, solid, compact bone by digital palpation. Evidence of the presence of a cyst can only be determined by a radiogram.

In cases of dentigerous cysts, where, upon digital palpation, there is evidence of fluctuation, the cystic membrane will be found directly beneath the mucous membrane; therefore, an incision should be made just through the mucous membrane and the cystic membrane should be retracted.

Where, upon digital palpation, the wet cardboard-like consistency of the overlying bone is determined, the incision is likewise made just through the mucous membrane, and after retraction of the flap, the overlying eggshell-like bone is removed with a pair of thumb forceps or hemostats, and the outline of the cystic membrane will be found intact. The membrane should be completely dissected from the bone and removed. Very often it will be found that after incision and removal of the overlying bone, an incision into the cystic membrane followed by the removal of the tooth, will facilitate the removal of the entire cystic membrane. The wound should then be irrigated and sutured, and the same postoperative treatment as outlined above should be instituted.

CHAPTER XXIV

TECHNIC FOR THE REMOVAL OF DEEPLY IMPACTED MANDIBULAR CANINES

At a recent dental meeting, ways and means of removing impacted teeth were being discussed. One of the oral surgeons present showed a radiogram of an impacted mandibular canine, the crown of which appeared to extend very nearly to the inferior border of the mandible. The radiogram was a small No. 1 dental film, from which a diagnosis of an impacted tooth could be made but which could not be used for determining its accurate location for an operative procedure. I was asked to outline the technic I would use in its removal. The answer was that I would first take a bite film, by placing a No. 2 dental film between the maxillary and mandibular dental arches, with the sensitive side of the film facing downward, and then directing the rays from below upward. The resultant picture would give an accurate localization of the impacted tooth. If the tooth was found to be lying midway between the two layers of bone or toward the buccal side, I would make a semilunar or semicircular incision midway between the superior and inferior borders on the buccal side of the mandible. The soft tissues should then be retracted downward and the overlying bone removed, beginning at the region of the apex. I would continue removing the outer plate following along the outline of the root until two-thirds of the length of the tooth was exposed; I would place a spear-pointed elevator under it and exert pressure outwards. In other words, instead of exposing the portion of largest diameter first, the apical end would be laid open, and in that manner, the tooth could be removed with a minimum of trauma and very little loss of bone. The reasoning was that the bone around the crown would probably be in a pathologic condition, exhibiting some decalcification, and that removal of the tooth could be accomplished without chiseling down to the point of its largest diameter. The oral surgeon then stated that he had removed the tooth externally. That is, he made an incision along the

lower border of the mandible on the outside of the face, retracted the tissues, and grasped the crown. This procedure, in my opinion, constitutes an unwarranted encroachment upon the tissues of the face. Oral surgery has advanced and has kept pace with the progress of general surgery. One of its chief claims to distinction as a specialty of modern medicine is the development of the intraoral operation. If operative procedures are adopted which have for their only justification the factor of accessibility, then we are reverting to a type of surgery which may have been pardoned forty or fifty years ago, but which can only bring the modern specialty of oral surgery into disrepute. Regardless of how neatly and skilfully an operation is performed through the external tissues it cannot fail to leave a scar. If it is a line scar it may ultimately disappear. If it becomes infected, however, it will leave a permanent scar. In either case it seems difficult to justify making an external incision when the intraoral operation is feasible. The case presented herewith is one of deep impaction, yet the tooth was removed by the intraoral method as outlined above.

CHAPTER XXV

IMPACTED MANDIBULAR PREMOLARS

These types of impacted teeth may be divided into two classes. The first class embodies the premolars which are partly erupted crowns exposed and occupying a lingual position in the arch; the second class comprises those cases in which there is complete impaction.

Teeth included in the first classification, because of the visibility of the crown, present a strong temptation for their re-

Fig. 227.—Impacted mandibular first bicuspid situated vertically. In this type of impaction care must be taken to have at least two-thirds of the tooth exposed before attempting to remove it.

The exposure of a small portion of the crown and grasping with forceps will result in fracture of the tooth, or if considerable force is exerted, in the fracture of the mandible.

moval by means of tooth forceps. The attempt to remove these teeth with forceps alone, without other surgical interference, will invariably result in a fracture of the tooth. Though the crown lies lingually, the root portion is generally toward the buccal side. An attempt may be made to remove these teeth with a pair of forceps. The procedure then is to use a thin beaked pair of upper forceps placed in position from the oppo-

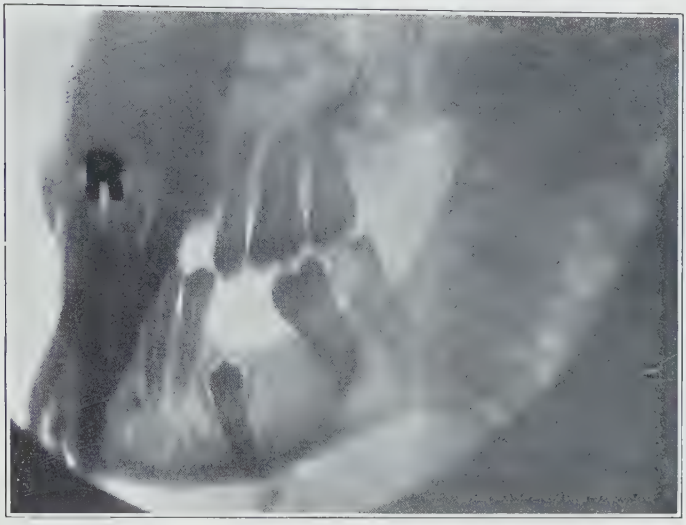


Fig. 228.—Impacted mandibular first bicuspid with root portion extending to the inferior border of the mandible. In this type of impaction care must be taken that only the external plate be removed and that no undue force be exerted in its removal.

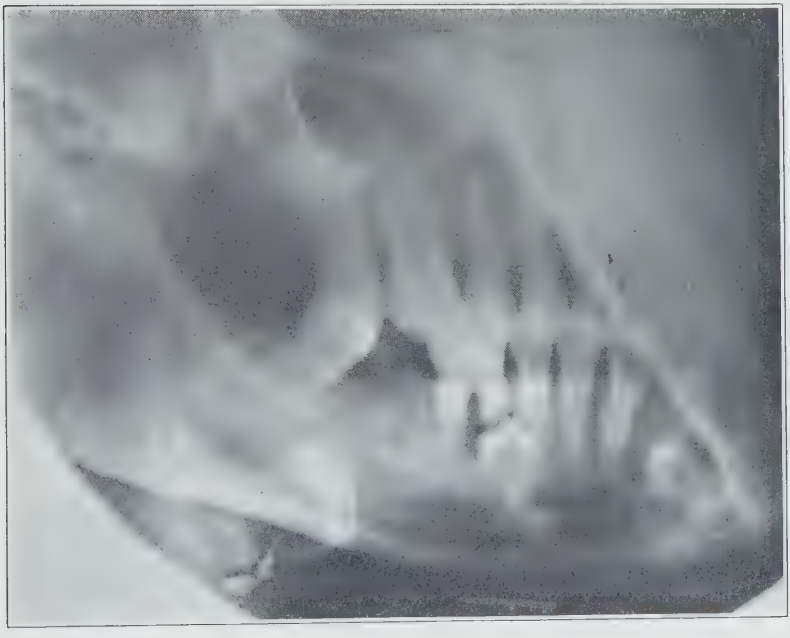


Fig. 229.—Impacted mandibular second biscupid causing absorption of the root (mesial) of the first molar.

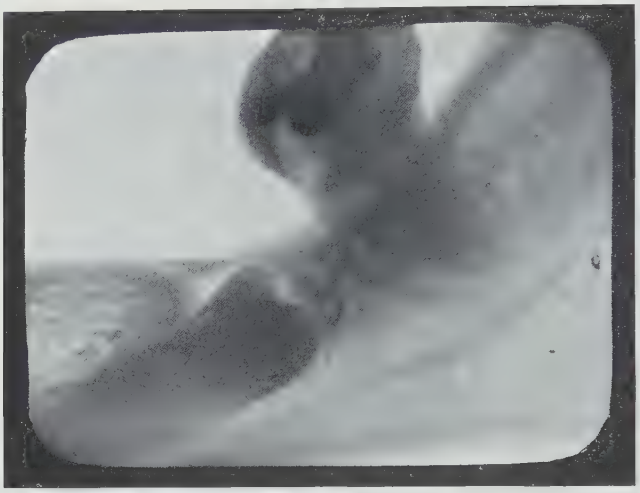


Fig. 230.—Impacted mandibular second biscupid lying diagonally, crown portion toward buccal, apex toward lingual.

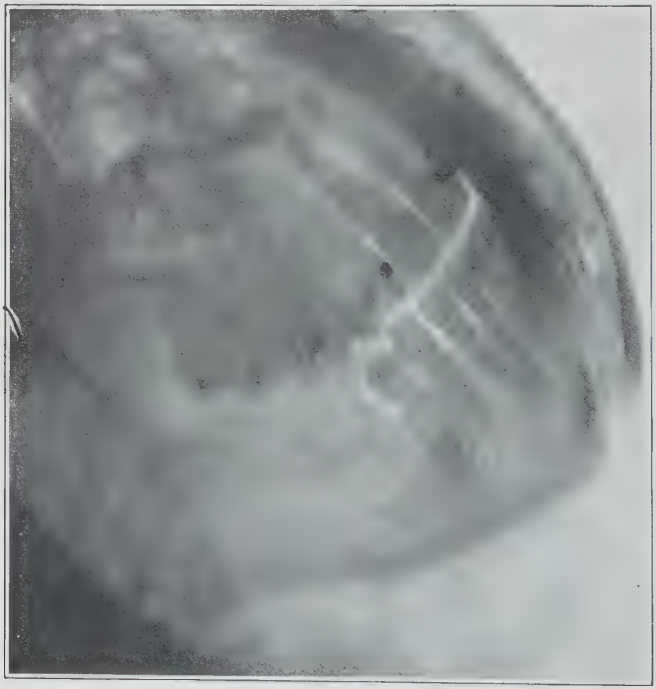


Fig. 231.—Impacted mandibular second bicuspid lying diagonally, crown portion toward the lingual, apex toward the buccal.

Fig. 232.—Impacted mandibular second bicuspid lying diagonally, crown portion buccally, root portion lingually.

Fig. 233.—Impacted mandibular second bicuspid.

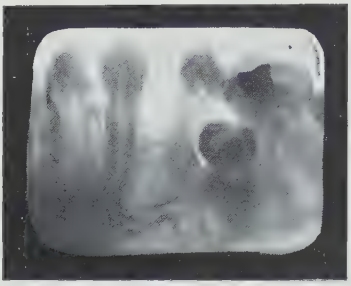


Fig. 234.—Impacted mandibular second bicuspid lying diagonally, crown portion lingually, apex towards buccal.

Fig. 235.—Impacted mandibular first molar. Incision should be made mesially, and carried posteriorly to second molar. To avoid possible fracture, the overlying bone covering the impacted tooth should be removed by the aid of the surgical burs.

site side of the arch, and to grasp the crown, exerting force in a downward direction. When this method fails, it is best, before an irreparable injury is caused to the adjacent teeth, to make an incision buccally and to remove the bone over the root portion.

The usual postoperative care should be instituted. In cases of completely impacted premolars the technic as outlined for the removal of horizontal impacted mandibular canines should be followed. Impacted mandibular first and second molars are not very common. The impacted mandibular first molar may best be removed by making an incision mesially to the crown and including the overlying gingival margin, with no incision pos-

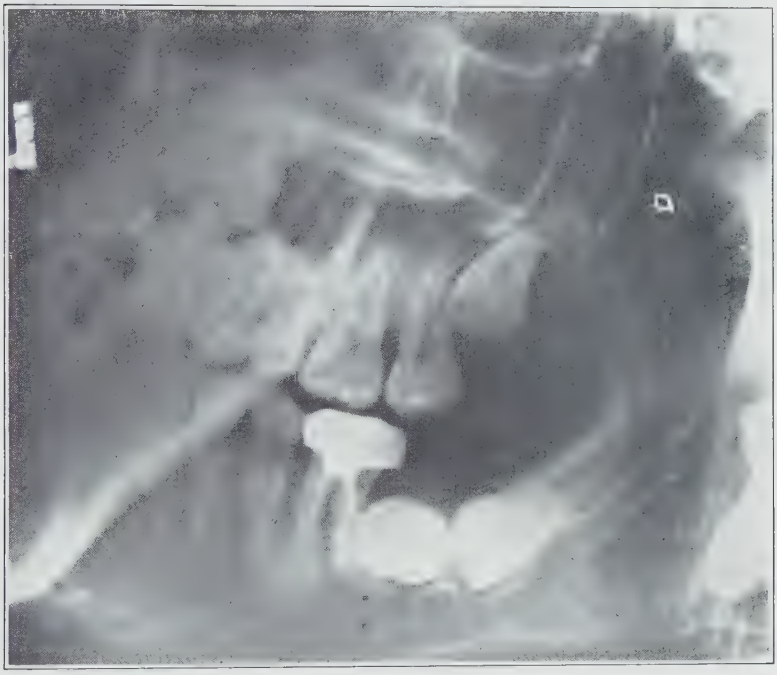


Fig. 236.—Bony type. Class 2. Note second molar which is a complete buccal impaction, very rarely found. In order to learn the curvature of the roots, x-ray as for the upper molar.

teriorly, retracting the tissues and exposing two-thirds of the tooth, then grasping the latter with a pair of forceps. The flap should then be brought back and sutured. One suture will usually be sufficient. Impacted mandibular second molars are generally associated with impacted mandibular third molars. When occurring individually, however, they should be removed in a manner analogous to that described *for the impacted mandibular first molar.*

Fig. 237.—Impacted mandibular second and third molars. Incision should be made in the center of the alveolar ridge, beginning posteriorly, and coming forward to the mesial surface of the first molar.

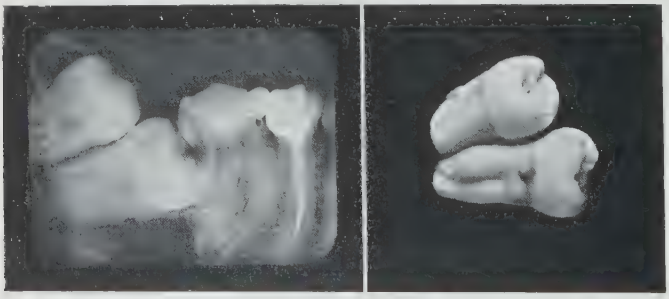


Fig. 238.—Impacted mandibular second and third molars. Incision for the removal of these teeth should be made in the center of the alveolar ridge, beginning at the posterior border of the last molar, coming anteriorly to the distal surface of the first molar, and downward to approximately the apex of the first molar.

CHAPTER XXVI

PERICORONITIS OR PERICORONAL INFECTIONS

The term pericoronitis is derived from the prefix peri, around, and corona, crown, and may be defined as an infection around the crown of a tooth. While academically these infections may

Fig. 239.—Dry specimen showing space between second and third molars. Outer layer of bone, ivory-like in appearance and consistency. Inner layer, honeycombed effect and spongy, permitting the insertion of spear-pointed elevator. By the aid of slight mallet force, the elevator may be forced down along the mesial surface of the tooth, and the tooth elevated from its socket.

occur around the crown of any incompletely erupted tooth, they are limited clinically to the mandibular third molar. A study of the regional anatomy of the third molar area will disclose the reason for the frequency of these infections. They may be either acute or chronic in character, the two types being sharply differentiated. In the acute type, pain and redness are constant with swelling and trismus invariably present. Rarefaction of

bone may or may not be present, depending upon whether the acute attack has been preceded by chronic infection. In chronic pericoronitis there is an absence of pain with but little or no edema or trismus. Bone rarefaction is always present and ap-

Fig. 240.—Radiogram of pericoronitis of mandibular third molar showing area of rarefaction distally to the crown.

pears as a slight variation from the density of normal bone. Chronic pericoronal infection may involve a completely impacted tooth, whereas an acute pericoronal infection cannot occur in such a tooth.

Acute infections occur only in cases where the crown is but partially erupted, its complete eruption being retarded by the overlying soft tissues, the adjacent tooth, or the anterior border of the mandible.

This overlying flap of so-called gum tissue contains fibers of the buccinator muscle externally and those of the superior constrictor muscle of the pharynx, lingually. Since these muscles bear an important part in the excursions of the mandible, and in deglutition, we can really understand the presence of trismus and difficulty in swallowing. The soft tissue of the flap acts as

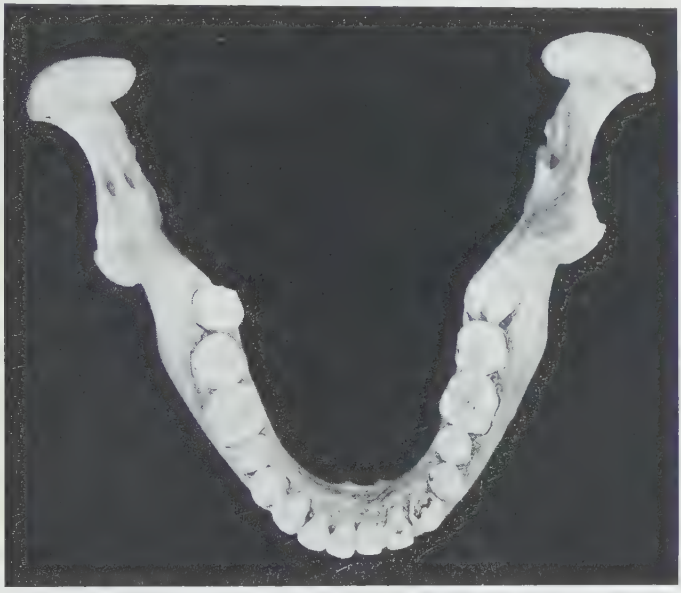


Fig. 241.—Dry specimen showing distribution of bone mesially to the third molar. In cases of this type no mallet force is necessary. The spear-pointed elevator is placed along the mesial surface of the tooth; the outer plate of bone is used as a fulcrum, and the tooth may be readily lifted from the socket.

a splendid media for the cultivation of mouth bacteria. This area is undisturbed by the toothbrush and the microorganisms in the presence of the necessary pabulum reproduce rapidly.

Radiograms

Radiograms are useless in the diagnosis of acute pericoronitis. The presence of this condition is determined in all cases by the naked eye. Proper radiograms will, however, aid the operator in deciding upon the technic to be employed when the removal

of the tooth is indicated. For example, if the radiogram discloses an area of bone rarefaction distal to the crown of the third molar, and the tooth is inclined mesially so that the mesial surface of the third molar is in contact with the distal surface of the second molar, a spear-pointed elevator is forced into the interproximal space, and force exerted distally and upward will result in the complete luxation of the tooth. It is important to remember that, in these cases, we are dealing with an infection of the soft tissues with only an occasional involvement of the bone. Recently I was called to one of the large hospitals in the city to see a patient suffering with what was supposed to be a most unusual condition. She had complete trismus of the jaws with a slight swelling on her right side. Radiographic findings were negative. Physical examination of the right side showed the presence of a distinct pericoronal infection. The patient was placed under a general anesthetic, the offending third molar removed, a dressing was inserted into the socket, and the wound irrigated daily for six days, at the expiration of which time the patient had made an uneventful recovery.

Symptoms of Acute Pericoronal Infection

Objective Symptoms.—Area of ulceration, suppuration, and extreme tenderness in the third molar region. The crown of the tooth may be visible, partially visible, or entirely obscured. There may be a distinct swelling on the lingual or on the buccal surface of the mandible. Fluctuation on the lingual or buccal surface in this region may also be present. In some cases the swelling on the lingual surface extends to the anterior pillar of the fauces. Trismus, partial or complete, is usually a concomitant symptom.

Subjective Symptoms.—Difficulty in swallowing, pain, offensive breath, and, depending on the severity of the infection, systemic disturbances, such as accompany any infection; namely, rapid and weak pulse, fever, chills, constipation, coated tongue, and malaise.

Treatment

The removal of the tooth and the establishment of drainage of the area is the safest and best procedure. This treatment may be followed regardless of the extent of the infection, or of

the amount of trismus present. A necessary precaution is the selection of the proper anesthetic. When complete trismus is present the administration of a general anesthetic is indicated. General anesthesia is indicated also in cases where there is but partial trismus or even where it is absent, if the infection has extended upward along the anterior border of the ramus of the mandible. Conduction anesthesia, anesthetizing the inferior dental nerve with a 2 per cent novocaine solution, may be employed in all other cases. Infiltration anesthesia, or injecting directly into the area, should be avoided. The danger in anesthetizing this area by means of infiltration anesthesia lies in the possibility of forcing some of the purulent material into the healthy adjacent tissue. Some operators advise the postponement of the removal of the tooth. This procedure has some very distinct advantages; the drawback, however, lies in the fact that, while the symptoms may clear up or improve, they generally become more aggravated and may increase in severity, particularly when the infection is on the lingual surface of the mandible. A retropharyngeal abscess may form, which constitutes a serious complication. Another group of operators advise against the removal of these teeth during the acute phase for fear that the creation of a fresh wound, where pus is present, might result in a severe infection. While this theory holds good in throat operations, it does not obtain where surgery is done in the buccal cavity.

Some operators advise the removal of the overlying tissue by means of escharotics, the actual cautery, or surgery. This procedure is successful in cases where no infection is present but is usually only of temporary value. In cases where the systemic as well as the local symptoms of abscess are present and digital palpation shows an area of fluctuation, in order to give the patient immediate relief, the abscess should be incised and the patient advised to use hot saline irrigations every hour to keep the wound open. Upon the subsidence of the acute condition the tooth should be removed.

Removal of Offending Tooth

When the radiogram shows the roots of the teeth to be straight, that is, when there is an absence of a mesial curvature

of the distal root, or a distal curvature of the mesial root, the tooth may be luxated out of its socket by the aid of a spear-pointed elevator. This technic is distinctly superior to the use of extracting forceps. The reason for this is that in the region of the third molar the overlying bone, instead of being of the honeycomb, spongy variety (alveolar process), is most likely to be hard, solid and compact,—of ivory-like consistency. The attempt to remove a tooth in this area by means of extracting forceps with the object of breaking down the wall of least resistance (the outer or inner wall of bone) invariably results in a fracture of the tooth, should the bone here be of the compact variety. On the other hand, a mandibular third molar, with straight roots, and no overlying bone of the anterior border of the ramus, may be lifted out of its socket.

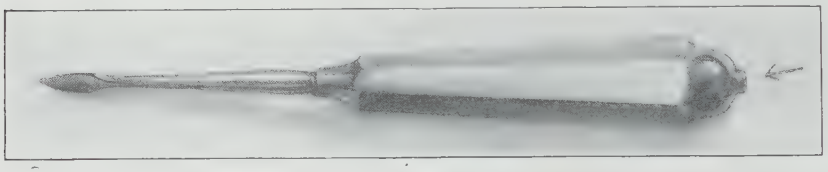


Fig. 242.—The spear-pointed elevator with steel rod running through center.

The procedure consists in placing a spear-pointed elevator along the mesial surface of the tooth which is to be removed. Care must be exercised not to place it along the distal surface of the second molar. With a few slight blows of the mallet on the head of the elevator (always supporting the jaw), force the elevator down along the long axis of the root. The outer plate of the mandible (not the teeth) should be used as a fulcrum, and the tooth forced upward. The tooth should not be completely forced out of its socket by means of the elevator, for in so doing it may be forced down the patient's throat. When the tooth has been partially raised out of the socket, it should be grasped by a pair of forceps and removed. The removal of mandibular third molars which have a peculiar curvature of the roots or which have a portion of bone covering the crown, will be considered elsewhere. The use of the mallet force in preference to hand pressure when using chisels, mastoid gouges, or spear-pointed elevators, is advocated for two reasons: (1) considering the extreme force necessary to cut bone by means of a

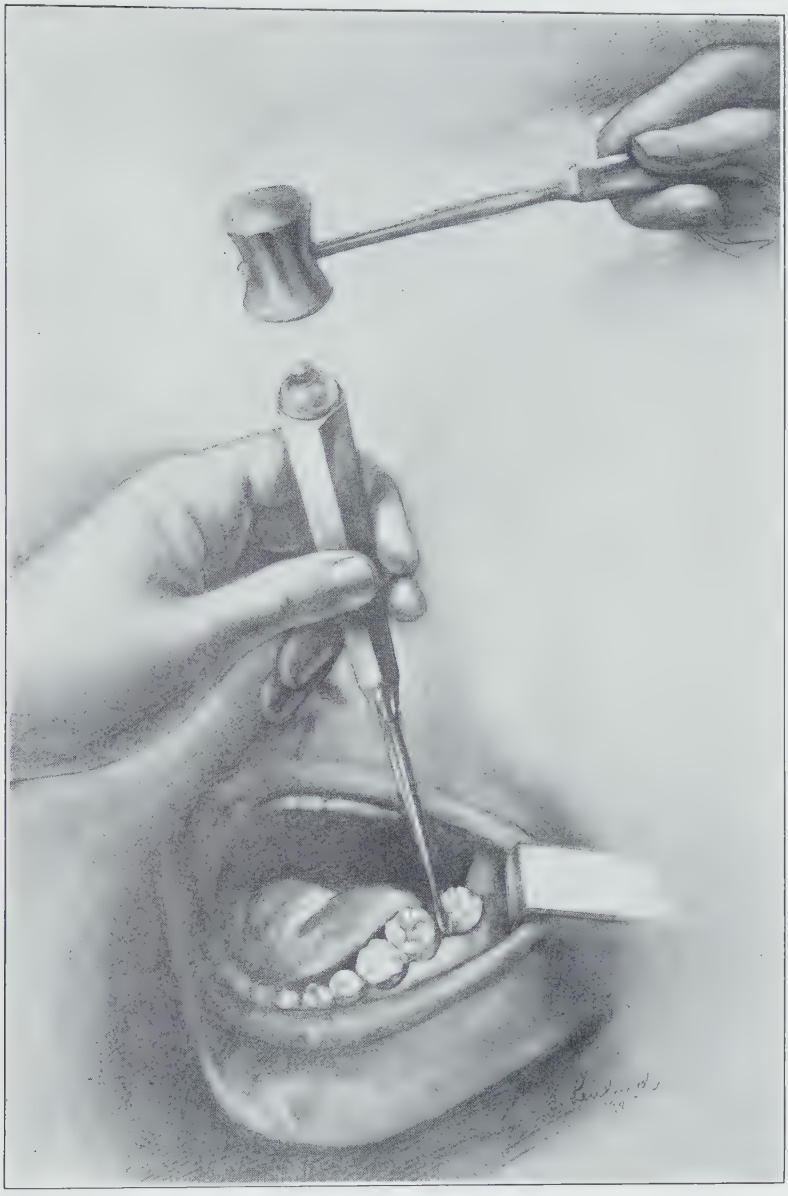


Fig. 243.—Showing proper position of spear-pointed elevator.

hand instrument, the procedure could not well be carried out under local anesthesia. The maneuvers necessary to cut bone by hand are such that, after the first attempt, few patients would permit the operator to continue, for fear of the produc-

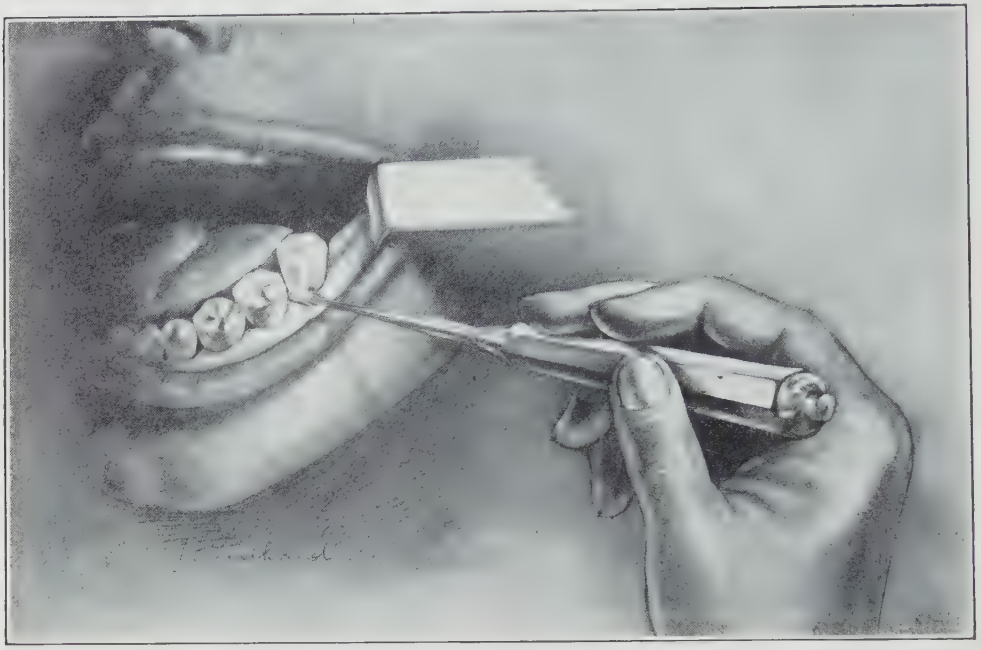


Fig. 244.—Using outer plate of bone as a fulcrum and partially lifting tooth out of its socket.

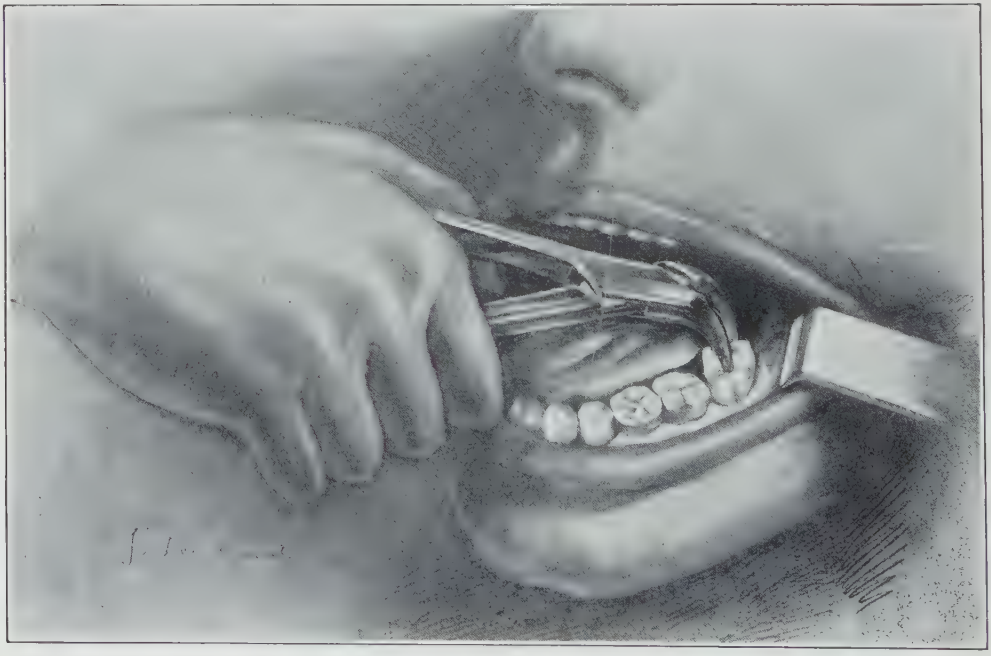


Fig. 245.—Grasping the tooth with Cryer Universal forceps after tooth has been loosened by the elevator.

tion of a fracture; (2) properly regulated mallet force when using gouges, or spear-pointed elevators in removing compact bone, in my opinion, is the safest procedure in the hands of the average practitioner.

In a large percentage of pericoronal infections of the mandibular third molars, the removal of the teeth so affected may be easily accomplished by means of an elevator without the necessity of resorting to the use of the mallet. It will be found that, by simply placing the spear-pointed elevator in position and using the outer layer of bone as a fulcrum, the tooth can be luxated out of its socket. A careful study of a series of radiograms will disclose the fact that in a large percentage of cases there is a distinct destruction of bone mesially, permitting the ready insertion of the elevator.

Postoperative Treatment

Following the removal of mandibular third molars with pericoronal infection, the wound should always be packed. This procedure should be carried out for two reasons: (1) to control hemorrhage; (2) to prevent reinfection of the wound.

Third molar sockets are situated where the use of a mouth wash in the ordinary manner is ineffective. Postoperative edema may be counteracted by the use of cold applications for twenty minutes every hour.

Postoperative pain will be greatly diminished and in a great many cases entirely eliminated through the use of a tampon of parathesin in the socket. In cases of severe postoperative pain the internal administration of a five-grain pyramidon tablet affords desired relief.

CHAPTER XXVII

IMPACTED MANDIBULAR THIRD MOLARS

The removal of an impacted mandibular third molar should receive the serious thought of the operator prior to the inception of the operation. Proper radiograms should be taken and

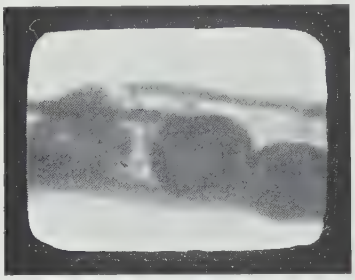


Fig. 246.

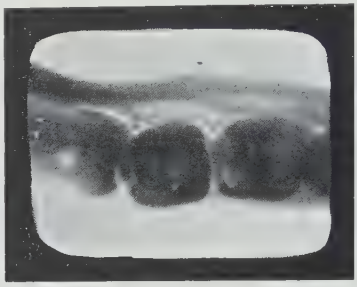


Fig. 247.

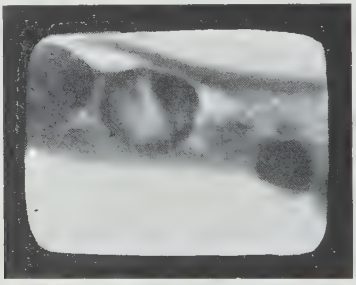


Fig. 248.

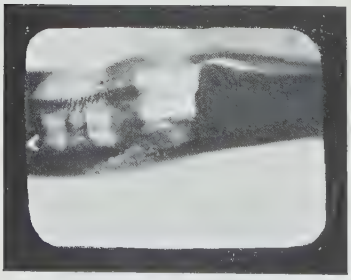


Fig. 249.

Fig. 250.

Figs. 246-250.—Illustrations showing how the taking of bite films will show the comparative thickness of bone on the buccal and lingual aspect of the mandible and spongy portion on occlusal aspect.

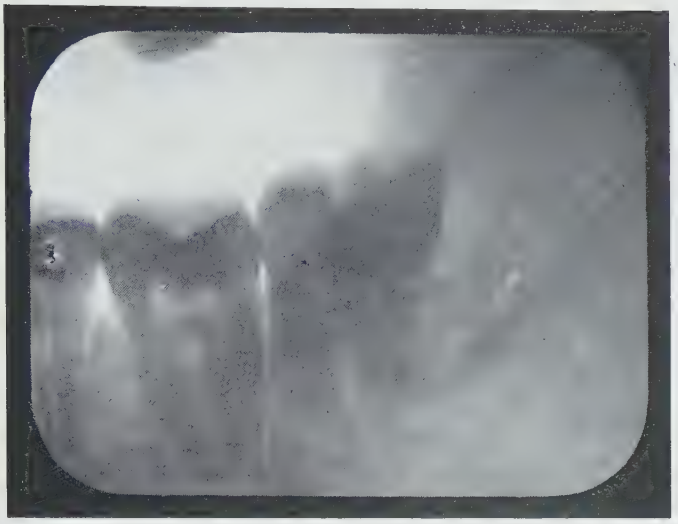


Fig. 251.—Tissue impaction is mistaken for bony type, because of shadow cast by external oblique line.

Fig. 252.—Tissue impaction.

carefully studied with a view to determining the nature of the overlying bone, etc. For example, if an impacted tooth has a very thin lamina of bone on its lingual aspect, undue force from the buccal surface may break down this layer of bone and force the tooth into the retropterygoid space.

Fig. 253.—Tissue impaction.

Fig. 254.—Tissue impaction.

Since the success in the removal of impacted mandibular third molars, especially the bony impactions, depends in great measure upon proper radiograms, the mention of a few general principles in taking these radiograms may not be amiss.

An extra-oral plate should be taken in all cases. This will give the size of the tooth, the curvature of the roots, the presence or

absence of a natural space between second and third molars, a general idea of regional osseous structures surrounding bone, or whether or not it is in close contact with the second molar.

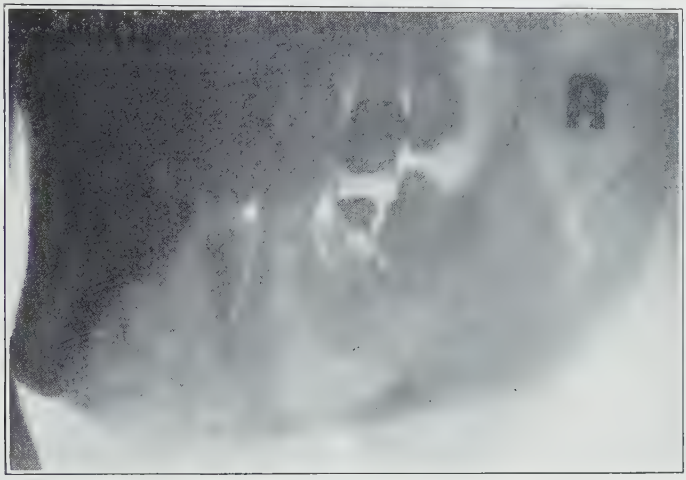


Fig. 255.—Tissue impaction.

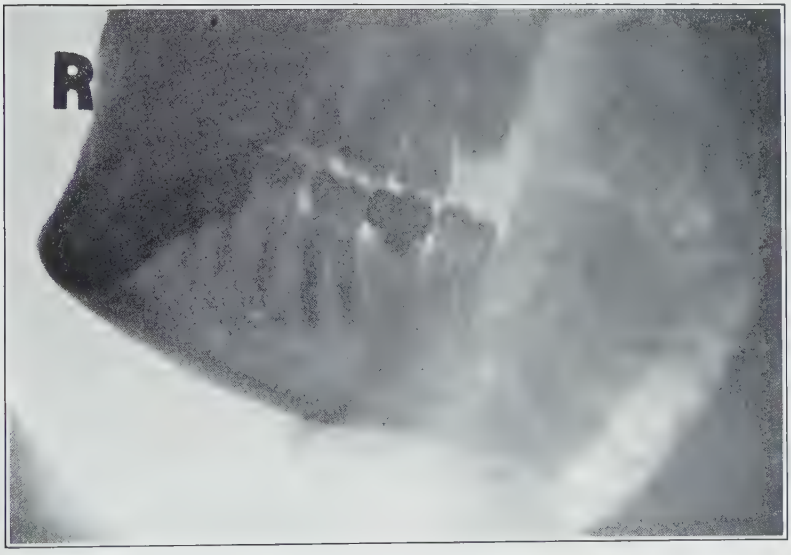


Fig. 256.—Tissue impaction.

For more exacting details, when in doubt, an intraoral film will be of aid. The next step is to take a bite film in order to determine the position of the tooth in the arch and to note how

much bone is to be used as a fulcrum. If the tooth is out of the line of occlusion, it is either to the buccal or to the lingual. If it is towards the buccal, the bone anterior to the crown is to be used as a fulcrum; if towards the lingual, the bone distal to the second molar is to be preferred as a fulcrum.

Fig. 257.—Tissue impaction on lower left. Relief must be made mesially on right side in order to gain entrance for elevator, providing tooth is not displaced buccally.

Impacted mandibular third molars are divisible into two main groups:

1. Tissue impactions,
2. Bony or true impactions.

A tissue impaction is a condition in which the tooth or the crown of the tooth lies directly beneath the soft structures.

Fig. 258.—Tissue impaction.

Fig. 259.—Tissue impaction. Radiogram should be carefully studied, noting root formation not only of third molar but also of second. Here we have a case with cone-shaped second molar roots; unless due precaution be taken to hold second molar with thumb, it may raise up out of socket when elevator is driven down.

Fig. 260.—Bony type, Class 1. Where we have space mesially for elevator and where relief is made distally, no difficulty will occur in removal.

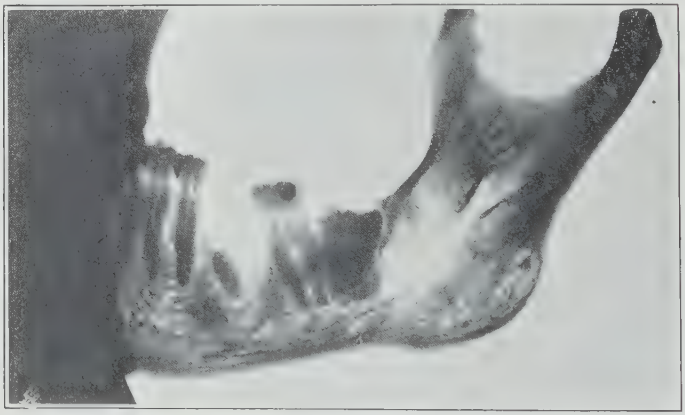


Fig. 261.—Class 1. Close contact with second molar may result in its loss; heavy roots will call for more than the ordinary relief distally.

These tissue impactions may be found in any of the following positions: (a) where the crown of the tooth is inclined towards the second molar; (b) where the crown of the tooth is inclined toward the anterior border of the ascending ramus; (c) where

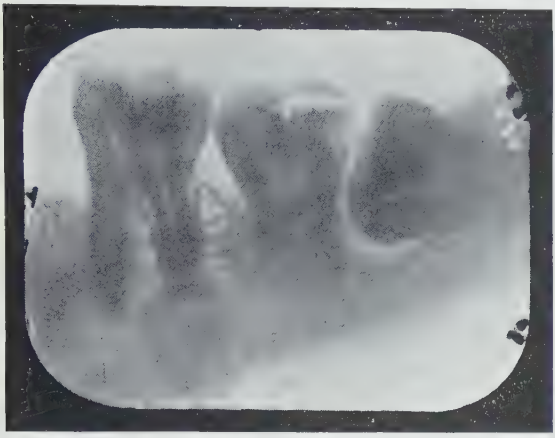


Fig. 262.—Bony type, Class 1. Pathologic area beneath crown portion. This type of impaction may be removed by placing a spear-point elevator under the crown and raising it upward without the use of mallet force.

Fig. 263.—Bony type, Class 1. Horizontal position, but with rare curvature of roots, namely towards mesial. Study radiogram carefully and note overhanging bone distally on anterior border which must be removed. Bone must also be relieved more than ordinarily anteriorly to gain entrance for elevator, because of mesial curvature of roots. An endeavor should be made to break up its resistance caused by this curvature by a few downward blows with mallet on crown of tooth.

the crown is impacted vertically; (d) where the crown is impacted horizontally.

For the removal of these teeth, an incision is to be made along

the center or slightly to the lingual side of the center of the ridge, with a slight turn downward toward the buccal. This incision will avoid the laceration of the overlying structures. A spear-pointed elevator is now inserted into the opening and passed along the mesiobuccal surface of the impacted tooth, the outer part of the body of the mandible being used as a fulcrum.

The leverage must be governed by the curvatures of the roots as disclosed by the extra-oral plate and the position of the tooth in the arch, as shown in the bite film.

Fig. 264.—Radiogram of Fig. 263.

Principles of Leverage Used, Governed by the Curvature of Roots

The most common type is where the roots are completely distal. In such instances direct the force downward, turn the elevator backward and upwards, and the tooth will rise out of its socket.

1. Where the mesial root is curved distally and the distal root is straight, just enough leverage must be applied to control the curvature of the mesial root; then, having the grooved buccal plate between the tooth and the external oblique line, use the elevator buccally and direct the force upwards. Where the roots are vertical, use upward leverage for obvious reasons.

Where the mesial root is curved distally and the distal root is curved mesially, a septum will be found between the roots which will offer great resistance. In order to overcome this factor,

place a spear-pointed elevator on the mesial buccal surface of the third molar and, with a few blows of a mallet, the septum will be fractured. Then use force directed upwards, of course presuming all resistance has been relieved.

Fig. 265.—Class 1. Where crown is directed distally, and roots are in close contact with those of second molar, follow-up radiograms should be taken to ascertain the condition of bone surrounding roots of second molar.

Horizontal types where roots are straight and thin are very liable to be fractured. In these instances apply direct force upwards.

Where the crown of the tooth is directed upwards into the ascending ramus, relieve the bone distally to gain entrance for the elevator of the Cryer type, having first relieved the bone

mesially. Using the ascending ramus as a fulcrum, direct the force forward, groove the buccal plate inside the external oblique line, and direct the force according to the curvature of the roots. In this type we often find the roots of the second molar destroyed due to close contact of the third molar roots.

Sometimes we find the roots curved mesially. This type of impaction fortunately is not common; it presents great difficulty, and unusual care should be taken to remove all resisting osseous

Fig. 266.—Bony type, Class 1. Where crown of tooth is in close contact with second molar, bone should be relieved distally, and lingual to the external oblique line. Slight groove should be made mesially in order to gain entrance for elevator.

structure prior to the application of the elevator, in order to prevent its being fractured.

When the tooth is standing alone, drive down mesially with a spear-pointed elevator and direct the force according to the curvature of the roots.

In edentulous mouths, use burs for removing bone and be careful in applying force because of the danger of fracturing the mandible.

In rare cases where the crown of the tooth is directed completely towards the lingual side, the method of determining the position of the roots would be to take a radiogram in keeping

with the technic used in the upper molar, directing the rays downward.

Bony or True Impactions

Bony or true impactions may be classified as follows:

1. Those above the superior border of the mandible, where we find the anterior portion of the crown exposed and the distal

Fig. 267.—Bony type, Class 4 standing alone. Relieve distally, driving down mesially; direct force upward.

part covered with overlying bone of various degrees of thickness.

Even though radiographic findings disclose the presence of a portion of bone distally, this latter need not necessarily be removed in order to luxate the tooth. This overlying bone is of varying consistency. When it is of the honeycomb, spongy

Fig. 268.—Bony type, Class 1. Relieve bone distally and but slightly mesially, for there is a natural space mesially for the entrance of the spear-pointed elevator.

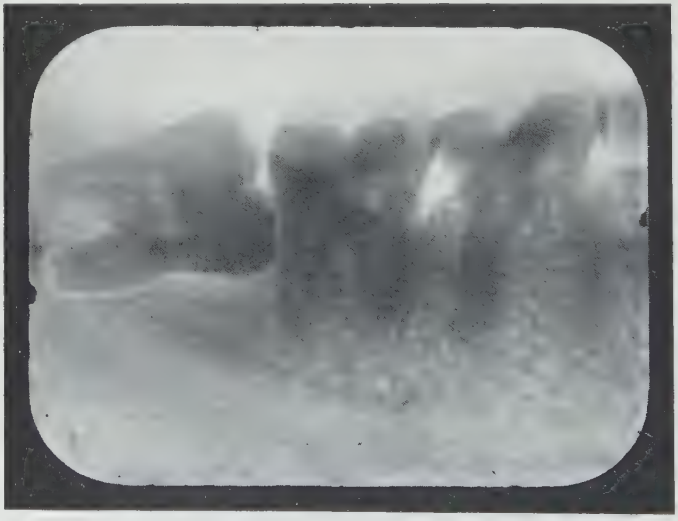


Fig. 269.—Bony type, Class 1.

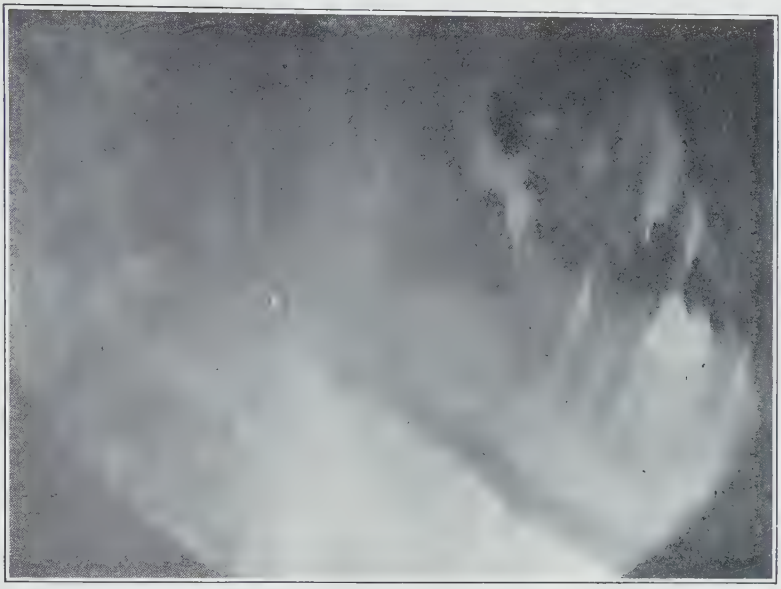


Fig. 270.—Bony type, Class 1.

Fig. 271.—Bony type, Class 1 calls for relief distally and mesially.

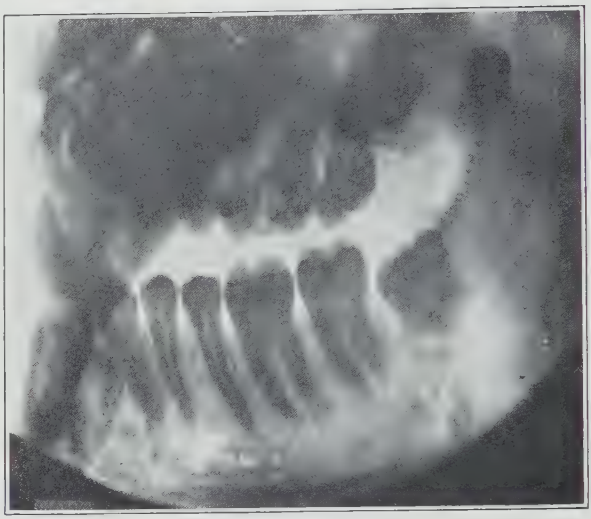


Fig. 272.—Bony type, Class 1. In line of fracture of the mandible. Force in removal must be entirely eliminated to avoid displacement of the fractured parts.

Fig. 273.—Class 2. Bony type illustrating technic used by some operators, whereas if bone were relieved distally and lingual to external oblique line and mesially to gain entrance for elevator, following the principles of leverage, the tooth can be raised out of socket without such loss of bone structure.

variety, as disclosed by radiographic findings, it will readily yield to the force exerted by the elevator.

There seems to be an erroneous impression that in this particular type of impaction the entire buccal wall must be removed to luxate the tooth. This needless destruction of tissue cannot

Fig. 274.—Bony type, Class 2. Right side. Bony type, Class 1. Left side.

Fig. 275.—Bony type, Class 2. Note spongy bone distally also mesially buccally. Groove bone just lingual to external oblique ridge, and also bone covering the occlusal surface of the tooth; then using the outer layer of bone as a fulcrum. Bite film will always show this spongy bone as well as width of arch.

Fig. 276.—Bony type, Class 2. Note spongy cancellous bone distally. The wide ridge gives the operator a natural fulcrum, by utilizing the external oblique ridge, after the bone has been grooved just lingual to the ridge and the portion covering the occlusal surface of the impacted tooth has been removed.

Fig. 277.—Bony type, Class 2. Type of mandibular third molar impaction. Where we have a thin lingual plate and the tooth is lying more to lingual, care must be taken so that tooth will not be forced out into the soft tissues. Should this accident occur, the index finger should be used to work the tooth up, out of the soft structures.

be condemned too strongly. In this type of impaction there is a great temptation on the part of the operator, due to the exposure of a portion of the crown, to extract the crown by the aid of forceps. This procedure will result either in the breaking off

Fig. 278.—Bony type, Class 2. Technic for removal of this type has been previously described. Note mesial curvature of distal root which complicates case.

of the portion of the crown exposed, or, if undue force is used, in the fracture of the mandible. Bone is not to be crushed, therefore, the use of any instruments, such as the cow-horn forceps, which have this for their objective, should be discouraged. In using elevators it must also be remembered that they cannot

be expected to do the impossible. When it is found that notwithstanding their judicious use we reach an area of undue resistance, careful search should be made to determine the cause

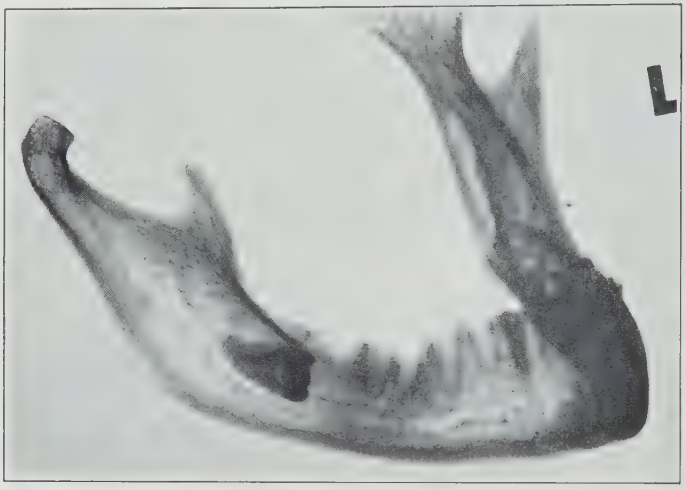


Fig. 279.—Class 2. Use burs to groove bone as described in text, so large sections can be removed with one or two blows of mallet in upward direction, and thus avoid excessive trauma.

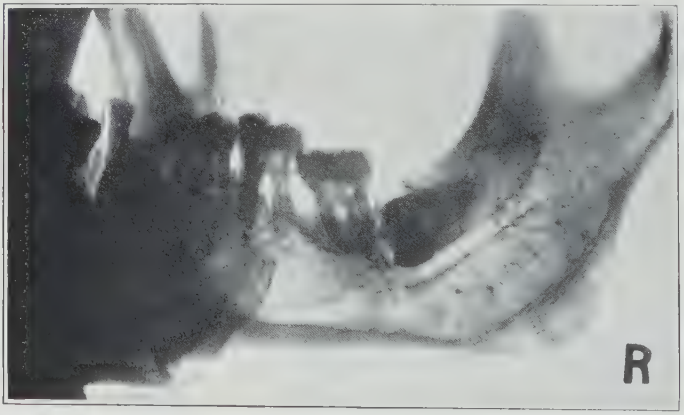


Fig. 280.—Bony type, Class 2. Note thin overhanging ledge distally.

of this resistance, which in most cases will be found to be either the anterior border of the mandible, or a peculiar root formation, such as hypercementosis of the roots, or a heavy septum between the roots, or exostosis of the roots.

2. Those below the border of the mandible and completely covered by bone. This latter type calls for extensive removal

Fig. 281.—Class 2. Note difference between bone covering crown of tooth and external oblique line. Bite film shows spongy bone lingual to external oblique line.

Fig. 282.—Bony type, Class 2. Deep-seated position.

of the osseous structures; but if correct technic is employed, much time and suffering will be avoided.

In very deep-seated impactions the following technic is suggested: knowing that the outer layer of bone is at most not over

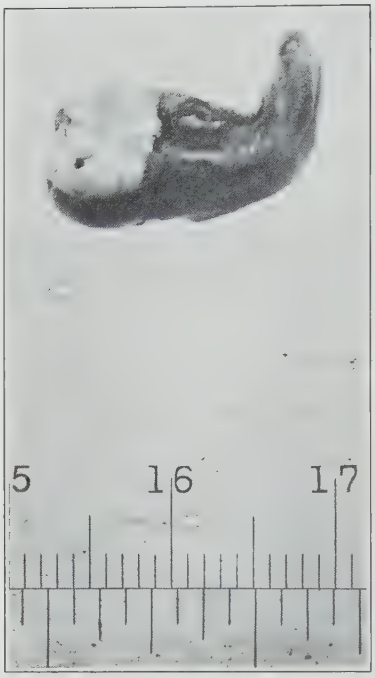


Fig. 283.—Bony type, Class 1. Pronounced curvature, such as this, calls for extensive relief distally.

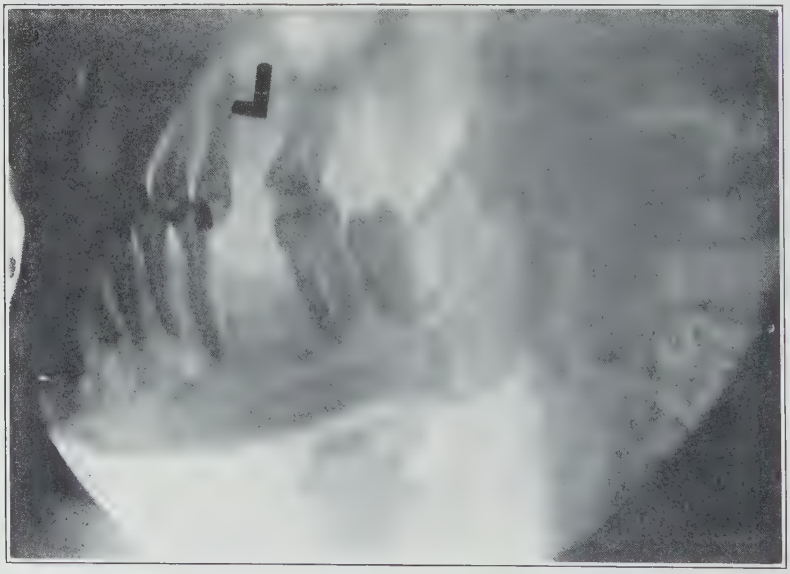


Fig. 284.—Bony type, Class 2. Pronounced curvature of the root or roots, as occurs in this case, calls for extensive relief of the bone distally. Note proximity of canal.

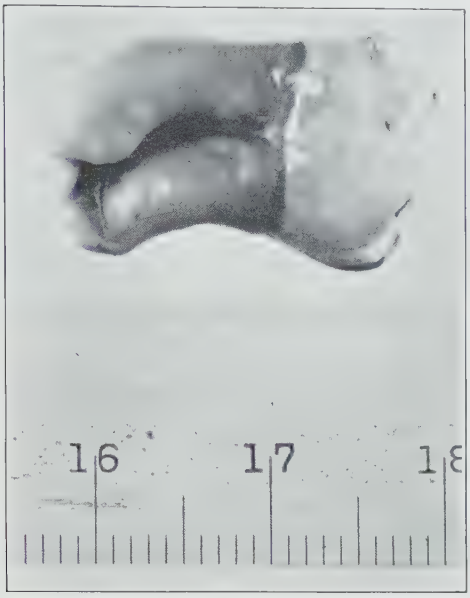


Fig. 285.—Bony type, Class 2. Note septum between roots which causes great resistance to its removal. The bone was relieved before attempting to elevate.

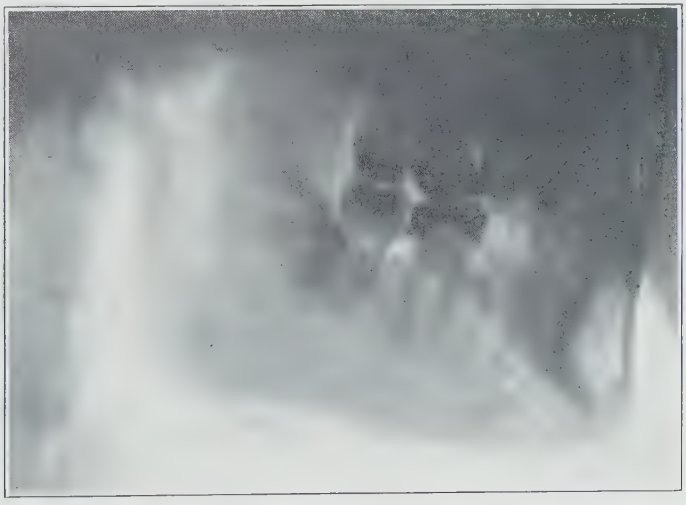


Fig. 286.—Bony type, Class 2. Horizontal position in ramus close to mandibular canal. Use technic described in text.

⅛ inch in thickness, and that the inner layer of bone is of a cancellous consistency, and having made an incision and elevated the mucoperiosteal flap, the operator with a spear-pointed bur, just distally to the second molar, makes a groove down to

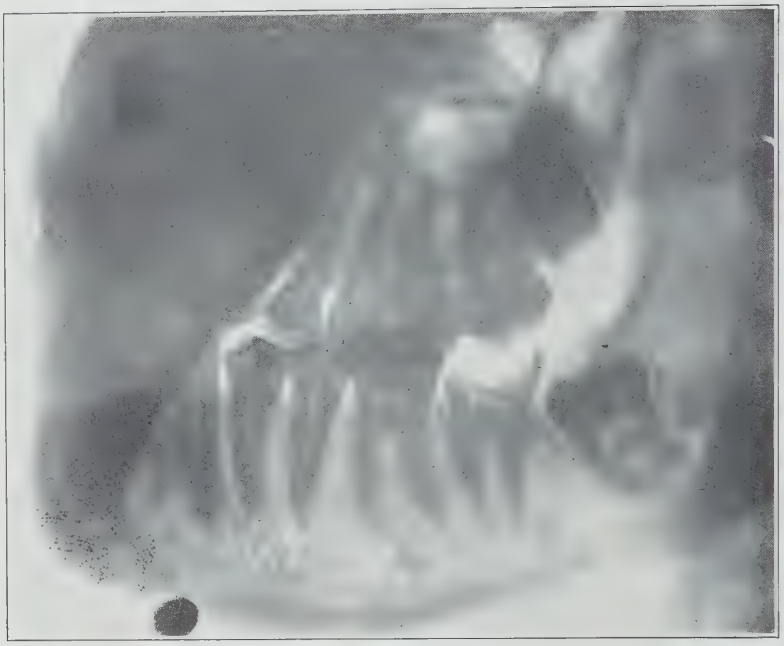


Fig. 287.—Bony type, Class 2. Note septum of bone between the mesial and distal roots, which offers considerable resistance to its removal, if not fractured by driving spear downward before attempting to elevate the tooth. Extensive relief distally must be made.

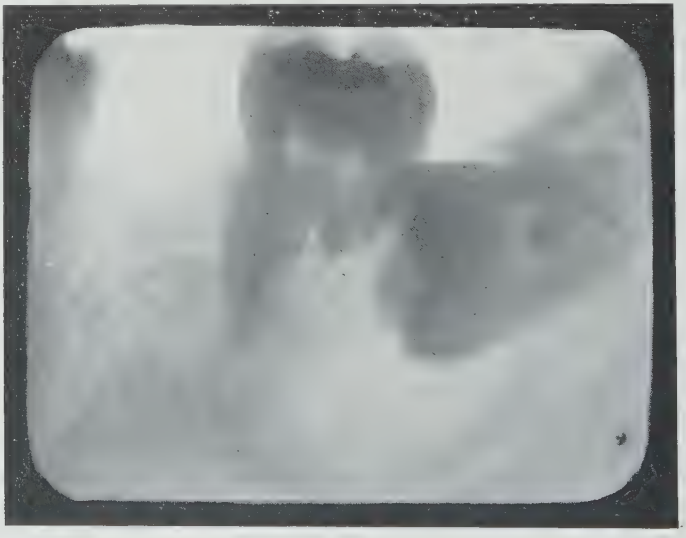


Fig. 288.—Bony type, Class 2. Marked destruction of distal root of second molar which calls for removal of this tooth as well as impacted tooth.

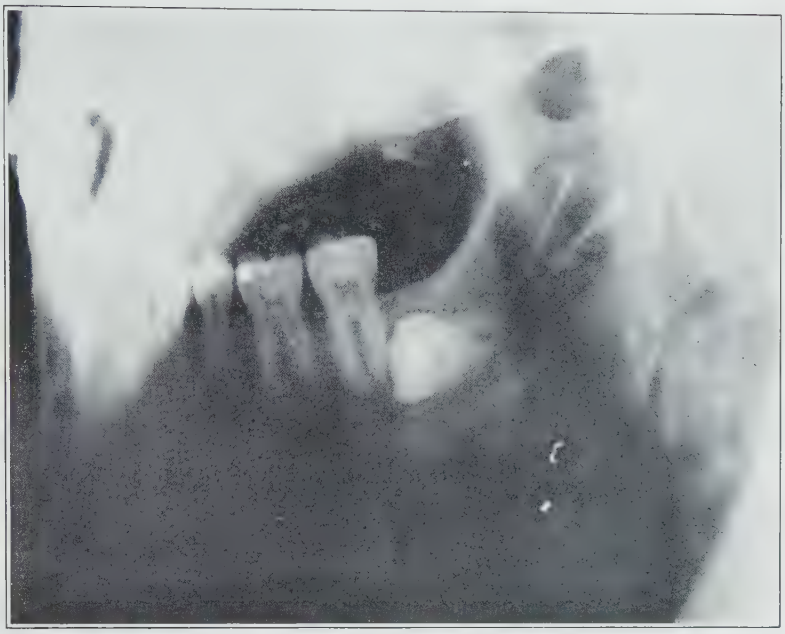


Fig. 289.—Bony type, Class 2. Loss of second molar may follow eventually, due to close contact.

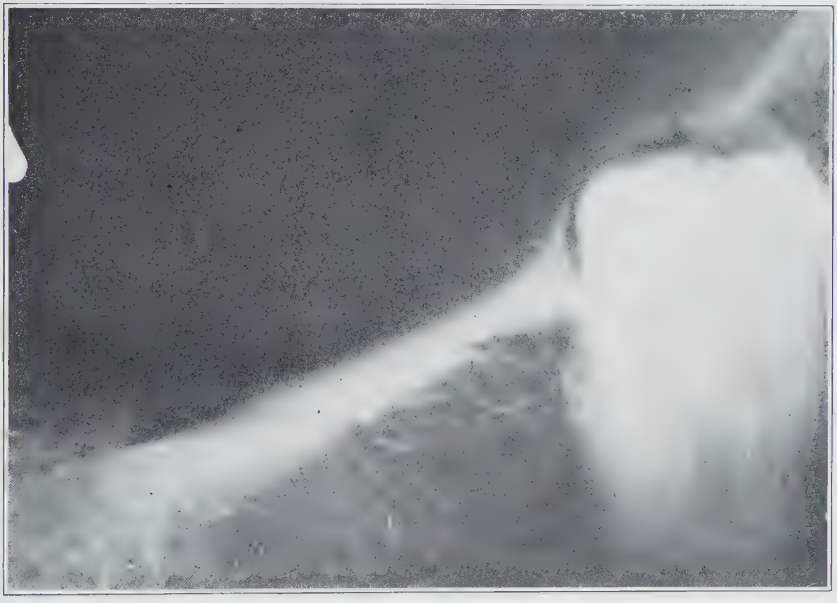


Fig. 290.—Class 2. Vertical type, edentulous mouth, being partially covered by anterior border of ascending ramus of the mandible. Burs should be used to remove the bone distally in cases of this type. Vertical type is the most difficult of all impactions.

the spongy portion on the occlusal surface to a point where resistance has been eliminated. He then grooves down on the buccal aspect, just below the center of the tooth, and then connects the two grooves mesially and distally. Thereupon placing a gouge on the buccal aspect, he directs a few blows of the mallet

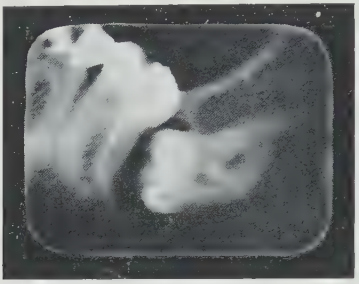


Fig. 291.—Bony type, Class 2. Marked destruction of bone mesially, necessitating the removal of the second molar as well as the impacted third molar.

Fig. 292.—Bony type, Class 2. Edentulous mouth.

downwards when the section will come away, or at least a greater portion of it, *en masse*.

The above technic will minimize trauma to the farthest degree. When the operator desires to eliminate entirely the use of gouges and mallet force, the bone may be removed by the use of surgical burs.

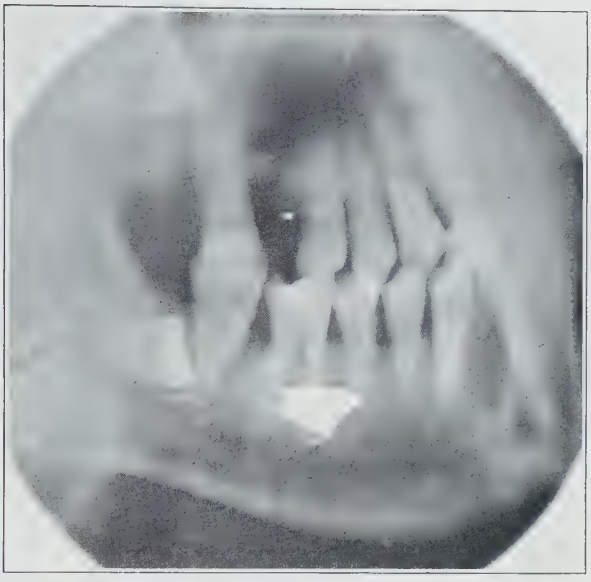


Fig. 293.—Bony type, Class 2. Removal of second molar as well as third molar being indicated.

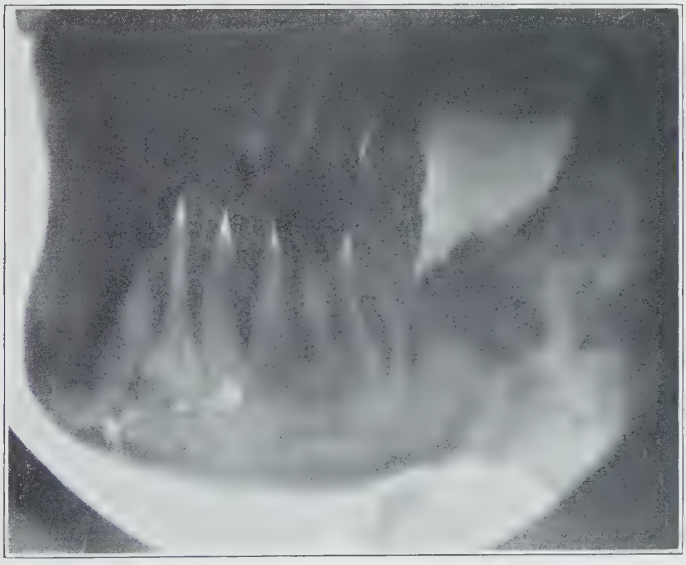


Fig. 294.—Bony type, Class 2. Where we find mesial root curved distally and distal root curved mesially, a septum forms between the roots, which is a great factor for resistance to its removal.

In cases of fracture of the crown of the tooth where a portion of the root remains, the following technic should be employed: where there is a bifurcation on the crown portion, together

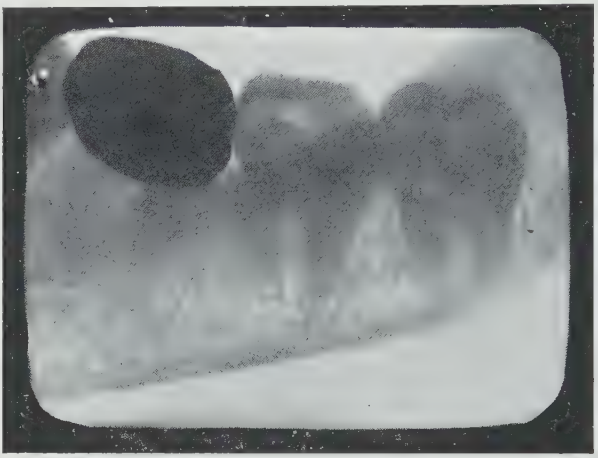


Fig. 295.—Bony type, Class 2. Note shadow of external oblique line.

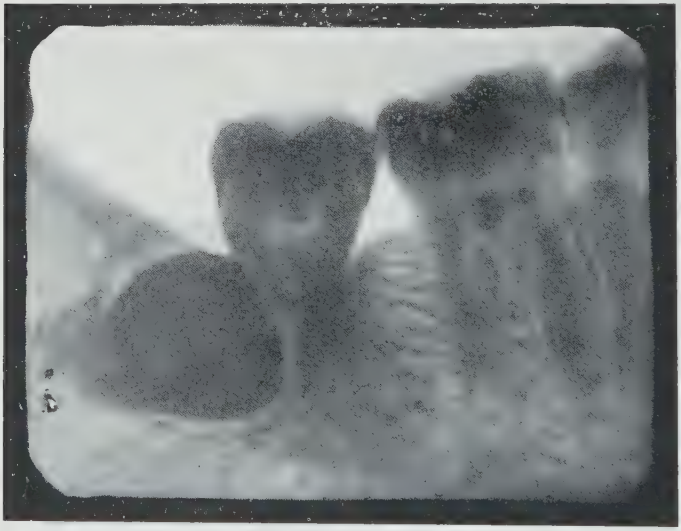


Fig. 296.—Bony type, Class 2. Crown of tooth directed towards the lingual surface and roots buccally. In order to ascertain the root formation, radiograms as for an upper molar should be taken when there is a complete lingual impaction.

with a multirooted tooth, it is necessary to reach the bifurcation by aid of a spear-pointed bur; thereupon separate the roots, insert the elevator in the space created by the bur, and loosen

Fig. 297.—Bony type, Class 2. In line of fracture of the mandible. When impacted teeth in line of a fracture are to be removed, the overlying bone should be removed by the aid of surgical burs. The use of chisels or undue force with an elevator may result in a displacement.

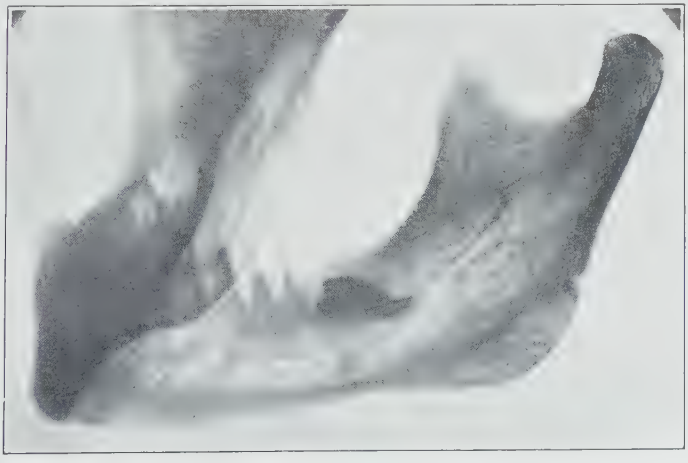


Fig. 298.—Bony type, Class 2. Edentulous area.

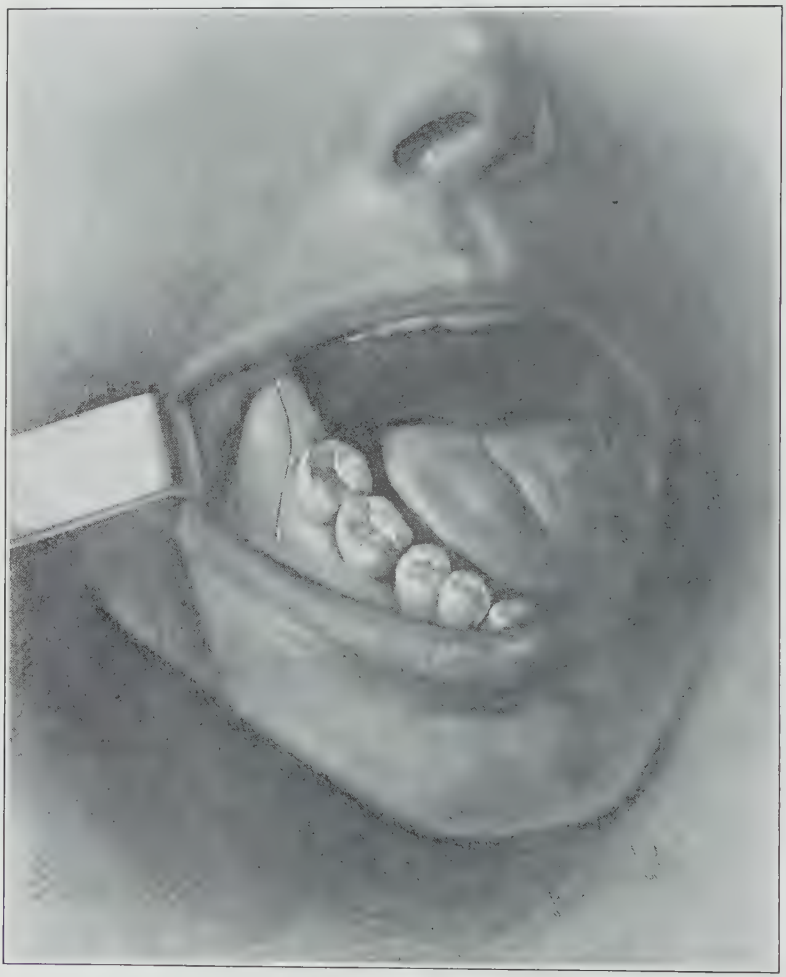


Fig. 299.—Nature of the incision for the removal of a completely impacted mandibular third molar. This incision should be used in cases where it is simply a tissue impaction.

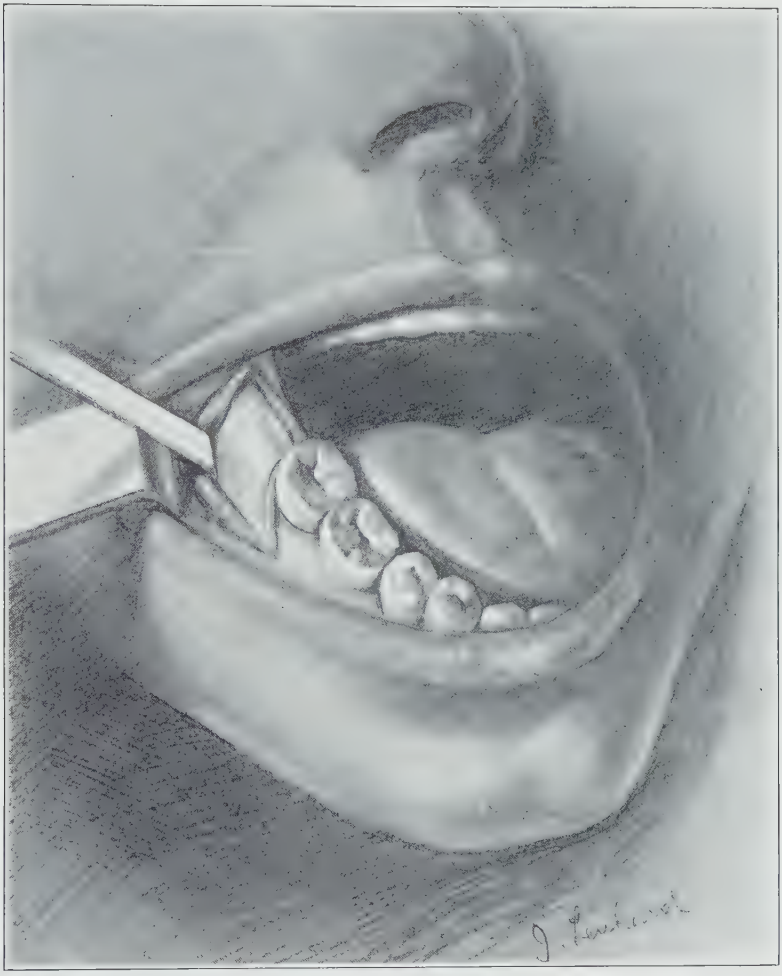


Fig. 300.—The retraction of the mucoperiosteal flap.

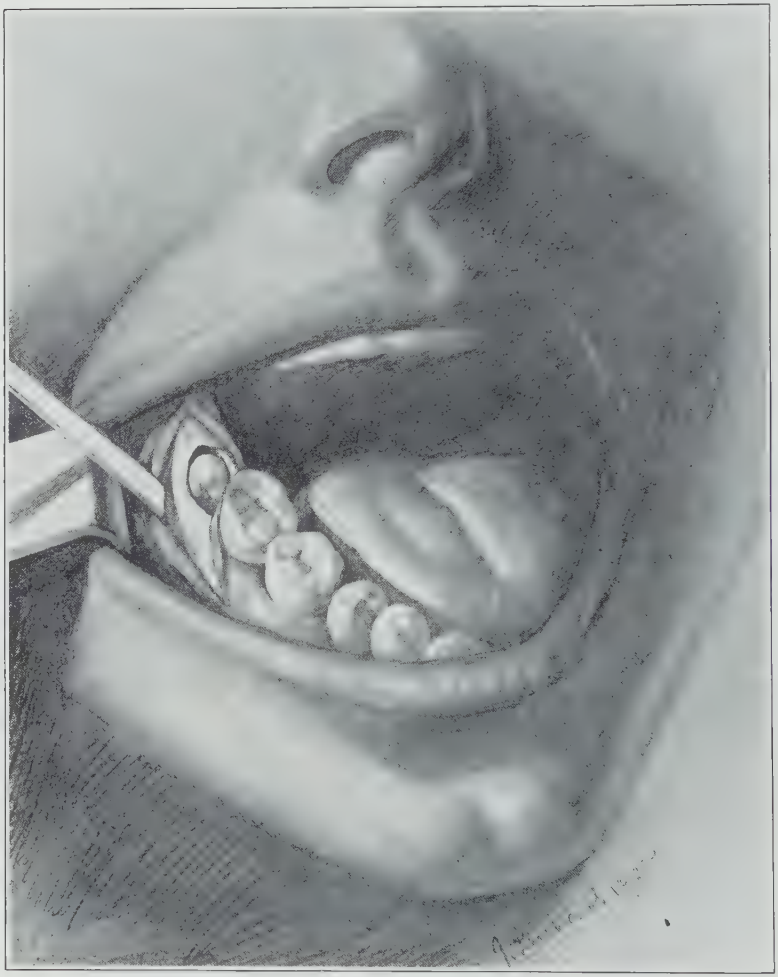


Fig. 301.—Showing a portion of the overlying bone removed.

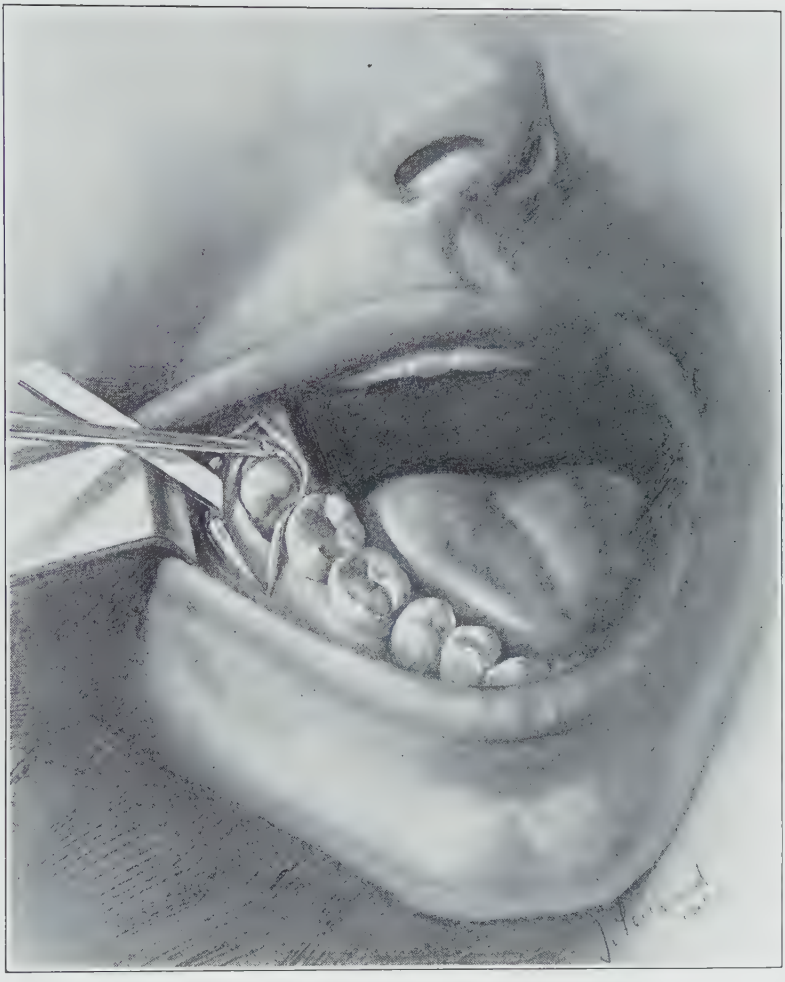


Fig. 302.—The use of the mastoid gouge for the removal of the anterior border of the ramus.

one root; then placing the elevator into the socket of the root elevated, break the interposing septum and loosen the other root.

In fused rooted teeth the buccal plate must be grooved lingually to the external oblique line, relieving bone distally, and a spear-pointed elevator should be inserted in this particular space and the root loosened up out of position. In cases where just the apical portion remains, an attempt should be made by

Fig. 303.—The use of the surgical bur for the removal of this overlying bone.

means of Ivory elevators to luxate this particular portion. In a majority of cases the use of this instrument will bring about the desired result; however, cases will present themselves where this particular apical portion will appear to be fused directly with the surrounding bone. To remove this apical portion, it is necessary to groove the immediate surrounding bone and to lift out the apex by the aid of a hooked instrument. The entire outer plate of bone covering this portion need not be disturbed in order to effect the removal of the tooth.

Great care must be taken to make all rough edges of bone

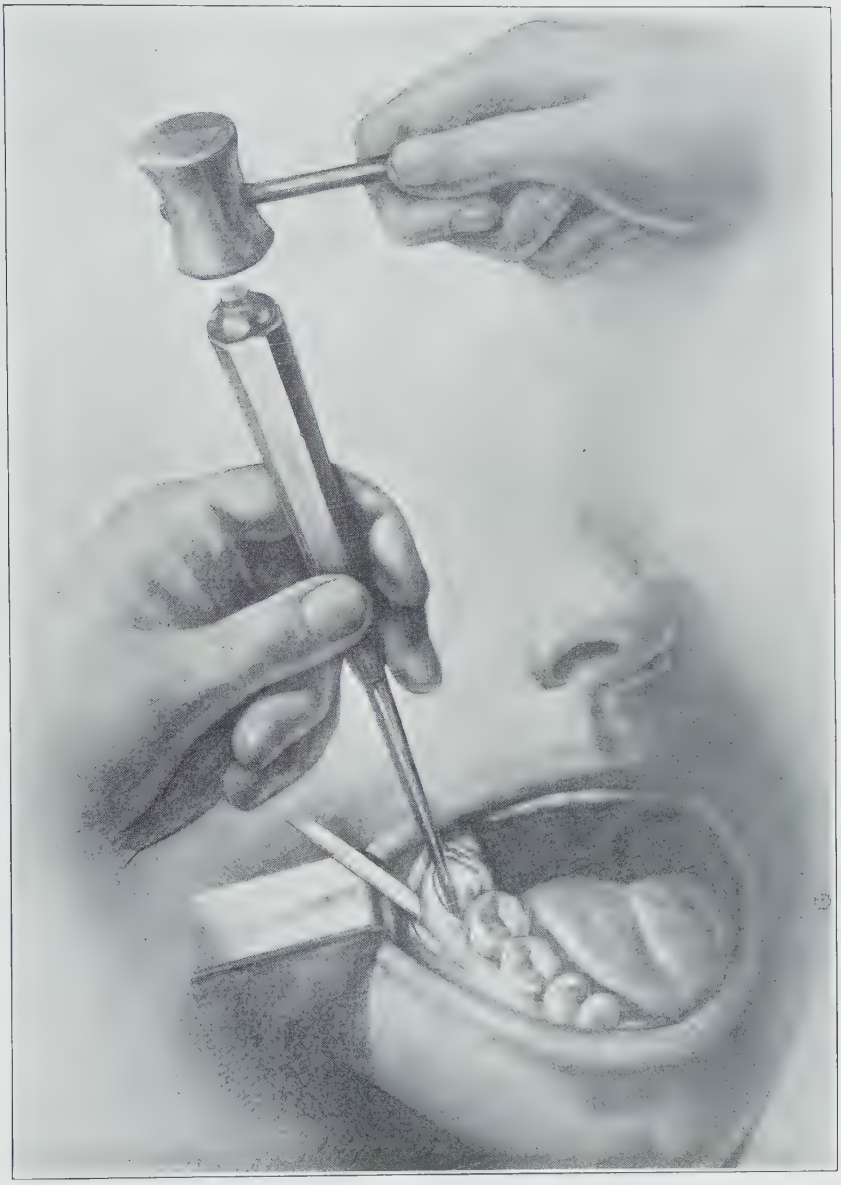


Fig. 304.—The position of the spear-pointed elevator (mesio-buccally). This elevator is forced down along the mesial surface of the impacted tooth, avoiding the distal surface of the second molar.

Slight mallet force will be sufficient to cause the penetration of the spear-pointed elevator a slight distance downward, for the bone directly adjacent to the impacted tooth is of the honeycomb spongy variety.

smooth; the wound should be thoroughly irrigated with a mild antiseptic, such as a weak solution of iodine, ¼₀ of 1 per cent, thereby removing all foreign particles and all portions of bone, and sutured, if necessary. A dressing should always be inserted following removal (1) to control bleeding, (2) to prevent infection of the wound. This dressing should be permitted to remain for twenty-four to forty-eight hours and subsequently the wound should be irrigated daily and customary dressings should be eliminated. In their place parathesin or paranol, in the form of

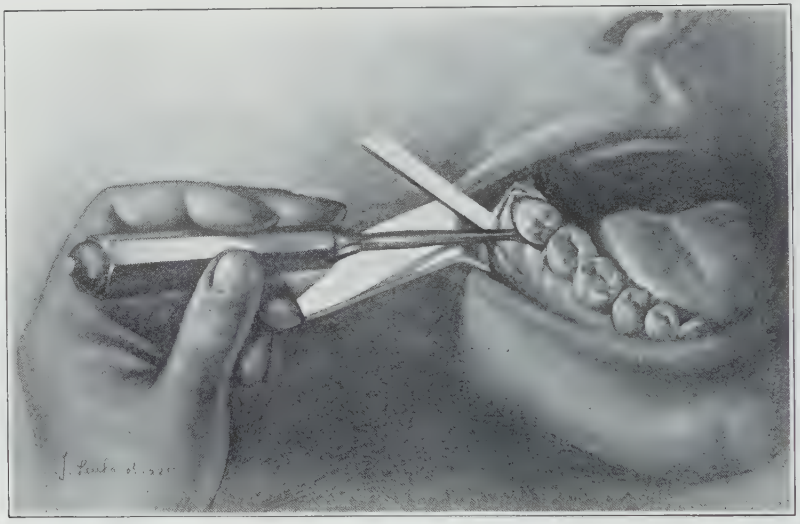


Fig. 305.—The use of the outer plate as a fulcrum to elevate the impacted tooth.

collapsules may be inserted into the socket. This will serve both as an anesthetic and as an antiseptic. In some cases, two or three weeks following removal of the tooth, there will be a slight swelling of the overlying mucous membrane with a discharge of pus from the socket. This pus is due to the breaking down of a fragment of loose bone or portion of bone which has been traumatized, with its resultant death and subsequent disintegration into the tissue. When this condition presents itself, the area should be anesthetized, and thereupon the socket and adjacent infected tissues should be curetted and then thoroughly cleansed, all débris being removed. Roughened edges of bone,

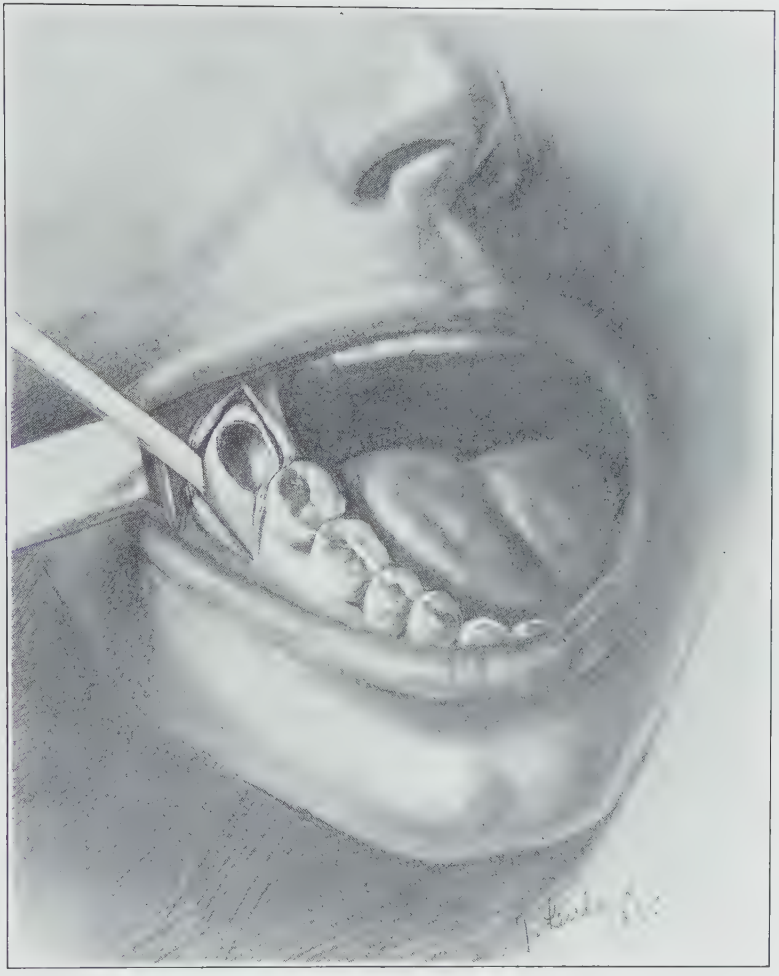


Fig. 306.—The wound with all sharp edges of bone made smooth.

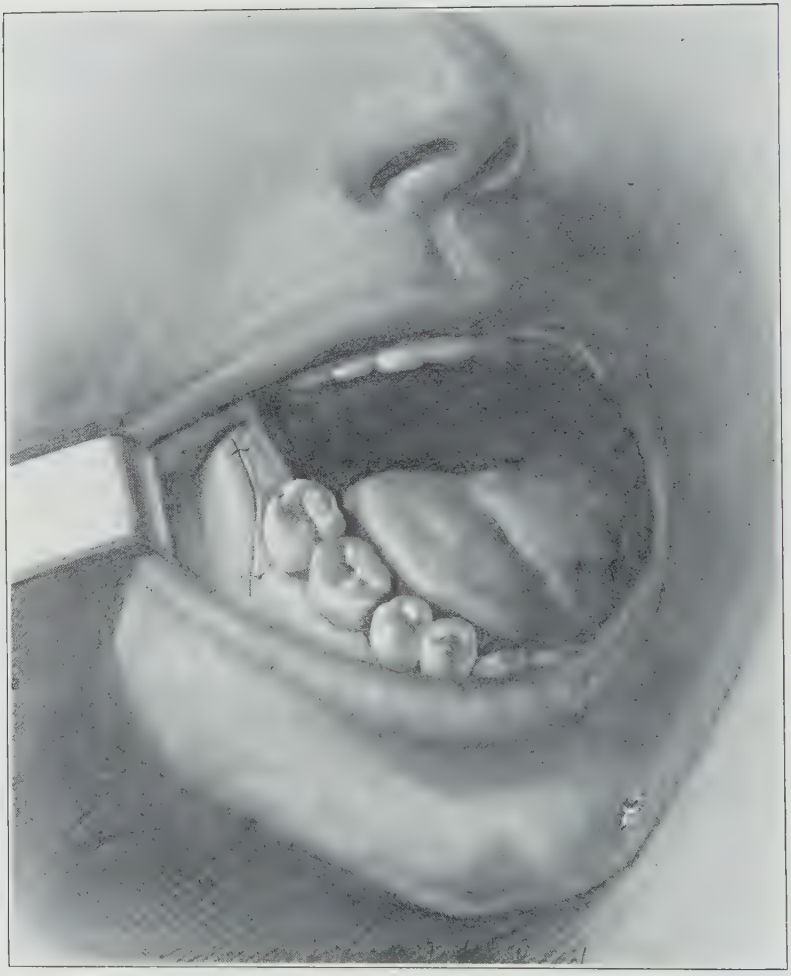


Fig. 307.—Flap brought back and sutured in cases in which this procedure is desired.

permitted to remain, may lead to the formation of hypertrophied tissue. This is also a factor which prevents proper healing of the wound and, when present, should be eliminated. Following the removal of deeply impacted mandibular molars, patients may complain of the absence of sensation in the lip or on the side of the tongue. This condition is undoubtedly due to injury of the lingual or possibly the inferior dental nerve, caused either by careless technic in operation or in anesthetization. The duration of this condition will depend upon the extent of the injury

Fig. 308.—Bony type—rare type—completely impacted in ascending ramus. If the radiogram is studied closely, the roots of the impacted tooth will be seen curved toward each other, forming a space between roots, with a great possibility of having the contents of the canal running through it.

Technic: the safest procedure would be to separate the roots and remove separately in order to avoid tearing the contents of the canal asunder.

and the period of time necessary to elapse prior to rehabilitation of the nerve fibers affected.

The removal of a second molar in order to facilitate the removal of an impacted third molar, in my opinion constitutes malpractice. This procedure should not be resorted to, except in rare cases and then only after consultation. When the second molar is diseased or the surrounding bone structure of this tooth is involved, necessitating removal regardless of the presence of the impacted tooth, the propriety of the operation is self-apparent.

Fig. 309.—Photograph of impacted mandibular third molar in the ascending ramus. The portion of the overlying ascending ramus should be removed by the aid of surgical burs.

Fig. 310.—Radiogram of Fig. 309.

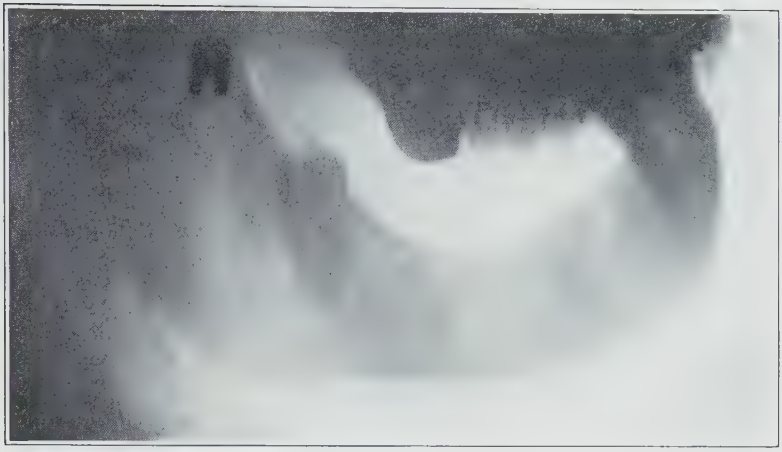


Fig. 311.—Impacted mandibular third molar. Edentulous mouth. Relieve bone distally with surgical burs. Leverage should be exerted in an upward direction. The shadow of the external oblique line is often mistaken for a heavy layer of bone.

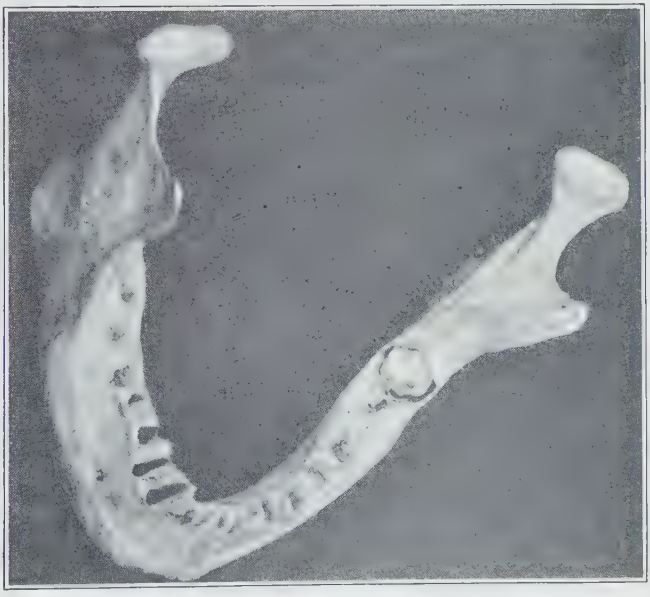


Fig. 312.—Horizontal impaction in ascending ramus. Relief made distally will be sufficient to elevate the tooth upward and draw it forward, due to loss of teeth.

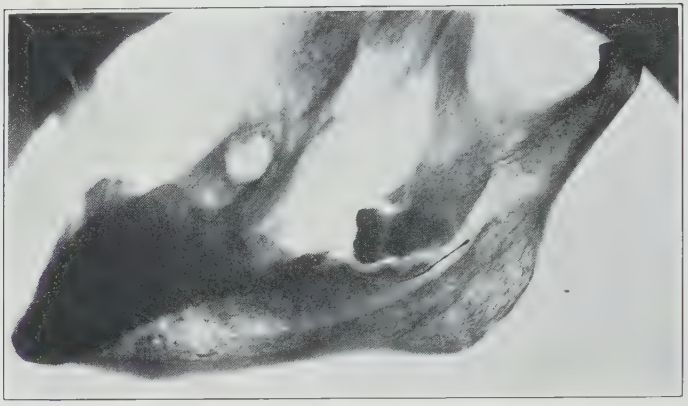


Fig. 313.—Radiogram of Fig. 312.

Fig. 314.—The result when a second molar is removed to permit the third molar to erupt. To remove the third molar, insert spear-pointed elevator mesially, and exert force upwards.

In cases where the second molar is infected beyond repair and its removal is imperative, and an impacted third molar is in position as well, then the removal of the second molar primarily will facilitate the removal of the impacted third molar.

Fig. 315.—Osteomyelitis following removal of mandibular third molar (impacted). When sequestrum has formed, as in this photograph, an incision should be made and the portion of the necrotic bone removed.

CHAPTER XXVIII

CYSTS OF THE JAWS

While elaborate classification of cysts of the jaw may be found in dental and in medical literature, I have found that all conditions of this variety may be grouped as:

1. Dentigerous, or follicular cysts,
2. Radicular, or dental root cysts.

Cysts are the most frequently occurring neoplasms in the jaw region. Skultetus, in 1654, first directed attention to the occur-

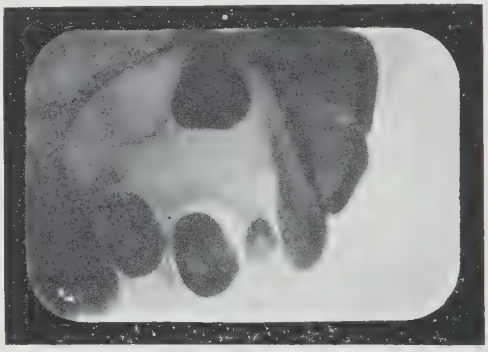


Fig. 316.—Impacted maxillary lateral and canine involved in dentigerous cyst.

rence of such cysts. He observed two cystic tumors in the upper jaw and it was his opinion that these tumors were closely related to the dental system. Bardenave and Mocelot, 1778, made a further study of jaw cysts and also described them, as also did Jourdain in the same year. The latter also determined the existence of teeth in the interior of cysts. In 1828, Delpeche, and Fouchard and Guibont made more specific and assertive reference to the existing connection between cysts and the dental system. Dupuytren, Diday and Forget were the first to furnish exact clinic data. Dupuytren described as a sure diagnostic characteristic parchment-crepitation, "Bruit de parchemin," a noise—other authors described it as an eggshell noise, "bruit de cognes d'oeuf,"—which develops from slight pressure upon the

PLATE II.

Illustration (drawn from life) of a follicular or dentigerous cyst, of the type where the outer layer of bone is of the eggshell consistency and where in one portion the bone has been completely destroyed. The bluish area is where the cystic membrane is directly beneath the mucous membrane. In this form of cyst the incision should be made with a Bard-Parker knife just cutting through the mucous membrane, being careful not to penetrate the underlying cystic membrane.

Fig. 317.—Dentigerous cyst of the mandible showing impacted canine tooth.

Fig. 318.—Impacted maxillary lateral incisors and canine, with canine lying directly beneath the zygomatic process, involved in dentigerous cyst.

thin bony cyst wall. On the strength of these clinical observations, the aspects of a disease formerly diagnosed as abscess or dropsy, could now be diagnosed as cysts.

Albrecht classifies cysts according to their place of origin and differentiates between thus:

1. Cysts imbedded in bones, and
2. Cysts bordering upon bones.

Fig. 319.—Impacted third molar with second molar involved in dentigerous cyst. Treatment requires incision in center of ridge, beginning distally and coming forward to mesial surface of second molar, and removal of second molar as well as impacted tooth and enucleation of cyst. Flap should be brought back and sutured.

Fackelday, 1869, made a more careful division, and differentiated as follows:

1.

1. Jaw cysts in preexisting cavities.
2. Cysts which are produced through softening of new-growths.

2.

1. Cysts which are due to diseased roots and penetrate the periosteum.

2. Pseudocysts which are caused by alveolar abscesses.
3. Cysts which develop from tooth-follicles.

3.

1. Cysts which are due to displacement of lip-glands during fetal development in the jaws.
2. Cysts which develop from the gland substance in the antrum of Highmore.

Fig. 320.—Follicular cyst of the mandible, showing impacted canine and first bicuspid.

In the removal of this type of cyst care should be taken to avoid pressure on the inferior border of the mandible, for a fracture may be caused, due to the destruction of bone.

Contemporaneously with Fackelday, Broca made a thorough investigation of jaw cysts, and he directed attention to the occurrences of follicular cysts. Magitot took up Broca's theory and added to it. His fundamental works made possible a sharp division of real tooth cysts. He differentiated between two groups:

1. Neogenic or periodontal and
2. Follicular tooth cysts.

By follicular cysts, Broca-Magitot understand cystic degeneration of rudiments of teeth, which has to do with deterioration of normal or excessive tooth pulp. Magitot's division has been recognized up to this time with the restriction, that "neogenic or periodontal" tooth cysts are now generally defined as radicular or root cysts.

To cystic new-formations are now added cystomas. We therefore differentiate between:

1. Radicular or root cysts
2. Follicular cysts and
3. Cystomas.

All three groups owe their origin to the epithelial tooth border. Radicular or root cysts develop from "débris epitheliaux paradentaires," discovered by Malassez and determined by Hertwig and von Brunn as residues of the epithelial sheath in the periodontium, the follicular cysts from the epithelium of the follicles, and the cystomas from the residues of the epithelial tooth-pulp itself. Root cysts are the frequently encountered jaw cysts. Of even rarer occurrence are cystomas. About their development, Partsch writes: "If the development of tooth-pulp is disturbed before its differentiation between connective tissue-like and epithelial elements, and if previous to that the tumor-like change of the enamel germ has commenced, tumors of an epithelial nature will result which, however, according to the changes to which they may be subjected, manifest different characters. The epithelium may proliferate in solid buds and thus give rise to firm tumors, or it may degenerate cystically, and in this manner produce so-called cystomas. These cystomas can be of a unilocular or of a multilocular kind. To the unilocular cystomas probably belong the so-called 'toothless' follicular cysts."

Magitot applied the development of follicular cysts to three different stages of tooth-development, as follows:

1. The embryoblastic.
2. The odontoblastic.
3. The corona period.

He attributed the formation of such cysts to the first period, in which neither tooth nor tooth rudiment, but only liquid is in evidence. The second period shows cysts with tooth-rudiments, and the third the completely formed tooth, or at least the completed tooth-crown. To Magitot's hypothesis, that development of follicular cysts are in direct relation with the rudiments of teeth, Malassez and after him also Albarran, took an adverse position. They would not recognize a difference in the genesis of follicular and root cysts, but considered as the cause for both groups "débris epitheliaux paradentaires." The reasons which caused Malassez to attack Magitot's theory, are:

1. A follicle damaged in its development cannot produce normal teeth.

2. The occurrence of several fully developed teeth in a cyst, as stated by Magitot, is hard to explain.

3. According to Malassez there are cysts, in which teeth or teeth rudiments are inclosed in the cystic wall, without being connected with the lumen of the cyst.

This controversy of Magitot-Malassez has been commented upon by Perthes, in his book entitled: "The Injuries and Diseases of the Jaw," to the effect that follicular cysts are due to the follicles themselves and not to "débris epitheliaux paradentaires." This opinion is also entertained by Partsch, to whom, however, it is not entirely clear to what extent the tooth-pulp and the epithelium of the tooth socket are instrumental in producing cysts.

The answer to this is as follows: Teeth may remain reactionless in the jaw without their owners being aware of their existence. Such teeth are occasionally accidentally detected through x-ray, applied for an entirely different purpose; or wearers of prosthetic appliances come to the dentist complaining that the appliance, which up to that time gave them no trouble, has become uncomfortable when it is discovered that there is a retained tooth, which through atrophy of the alveolar process is beginning to cut the tissues.

While a part of the retained tooth remains unaltered in the jaw, another part gradually undergoes resorption. Nothing definite is known as to the causative factors of resorption. Again

we find retained teeth which are surrounded by follicular cysts. Here the question arises: is the retention of the tooth primary and the cyst formation secondary, or does the cyst form first, and is the tooth therefore prevented from cutting through?

The formation of follicular cysts proceeds from the epithelial lining of tooth-sockets. Partsch, as mentioned before, is uncertain to what extent the lining is instrumental in the formation of follicular cysts. It is not the entire follicle which degenerates cystically, but primarily a germ field is established at a certain point. Through the confluence of several epithelial strands which are located in the interior of the germ field, a large cavity is formed and thereby the primary cyst in the wall of the follicle is established. Only as a secondary condition does the cyst gradually take in the entire follicle. We then have a picture of the follicular cysts, as they are observed in the majority of cases. At the bottom of the cyst is the tooth-crown, which projects into the lumen; the cystic wall adheres firmly to the neck of the tooth and surrounds the tooth in the form of a cap. The germ field of follicular cysts corresponds absolutely to that found in root cysts. Consequently the histologic behavior and growth of follicular cysts is the same. Macroscopically, the cyst-sac consists of a solid connective tissue-like outer coat, one to several millimeters thick, and of an inner epithelial layer. This epithelium is of the pavement variety. The longer the cyst exists, the thinner the layers become. They originate from the epithelial lining of tooth-sockets.

The long-existing theory of secreting epithelium was discredited by Romer as follows: How can such epithelial cells secrete when they are in the stage of decay? How is it at all possible for protective epithelium to secrete, when, according to our present knowledge, it was never able to exercise secretory functions? Romer rather assumes that the generation of the fluid, which is instrumental for the growth of cysts, is due to hydropic degeneration of the connective tissue cells in the interior of the epithelial masses.

Partsch assumes a mucous degeneration of the connective tissue cells. So far genuine mucus has not been determined in the cystic content through specific coloration.

Proell believes that he has proved fatty degeneration of connective tissue cells. Fat is always found in cystic fluid (at times in considerable amounts). Recently Partsch concurred with Proell's opinion. The presence of cholesterin in the cystic content—cholesterin is met with much more frequently than has been generally assumed so far, and it is also found in follicular cysts—could be associated with fatty degeneration of connective tissue cells. It is also highly probable that fluid escapes from the capillaries. Further growth of cysts proceeds in such manner that the secondary cysts, which are located in the cystic wall, through constant growth, finally burst and, therefore, continually augment the content of the "mother-cyst." Through this perpetual content-augmentation, the cyst exercises a steady pressure upon the bone which surrounds it and slowly, but surely brings about its disappearance. The causes which lead to the formation of a germ field and, therefore, to cyst formation in the wall of follicles, are entirely unknown at this writing. Trauma has been accepted as an incidental cause by different investigators. In my opinion no doubt can exist on this score.

The chief cause for a cyst development is to be found in the individual disposition. This is attested to by the fact that many patients, in spite of numerous teeth, which somehow lost their pulp-content, or with retained normal or excess teeth, never showed a cyst formation of a radicular or follicular type. On the other hand there are patients, who develop a root cyst on nearly every tooth which does not continue to possess living pulp, or in whom each retained tooth-rudiment degenerates cystically.

The chief points which present themselves for consideration for the existence of follicular cysts are as follows:

1. Broca-Magitot's opinion is correct. The follicular cyst develops in the follicle of a retained tooth-rudiment and not from "débris epitheliaux paradentaires." (Molassez.)

2. The primary factor is the retention of the tooth.

3. Thereupon, initially, in one part of the tooth-socket a germ field is formed from which the primary cyst develops.

4. Only gradually does this primary cyst involve the entire follicle.

5. The causes which are responsible for the formation of follicular cysts are yet unknown. Above all, individual disposition is responsible. Trauma must be considered as an exciting cause.

Dentigerous cysts are more commonly found in the upper jaw than in the lower jaw. The cause for this lies in the fact that the upper canine teeth are most frequently retained. The retention of a tooth is a predisposing cause to the formation of a follicular cyst. Supernumerary retained teeth are also more frequently met with in the upper than in the lower jaw.

Inasmuch as these follicular cysts do not produce pain, they may grow unknown for years in the interior of the jaw. As they increase in size, they gradually distend the bone, attenuating it until it finally has but a shell-like consistency.

The tumor which becomes externally visible in this stage, projects from the jaw. It is marked by sharp borders. If the softening of the bone has progressed sufficiently, a sharp-edged bone defect is palpable at the acme of the swelling. By palpating the swelling, pulsation of the cystic-sac can sometimes be felt. Parchment-like crepitation is clearly discernible at this time. The faint bluish-glimmer of the cyst can be seen through the mucous membrane covering the tumor. As cysts, conforming to physical rules, always develop in the direction of least resistance, they most usually convex the buccal wall in the lower jaw, and the buccal or palatal wall in the upper jaw, according to their place of origin. Cysts emanating from the upper bicuspids or molars usually project into the antrum of Highmore; they are even able to embrace most of the upper jaw cavity, so that ultimately this cavity is confined to only a small area.

While root cysts usually develop from the alveolar processes (only very large cysts involve the adjacent regions), follicular cysts are met with at all points on the upper and lower jaws. In the upper jaw, they appear on the hard gum, in the antrum, on the processus frontalis and even in the orbita; in the lower jaw they occur mostly on the angle of the mandible and on the ascending ramus. The latter, which always emanate from the third molars, deserve special consideration.

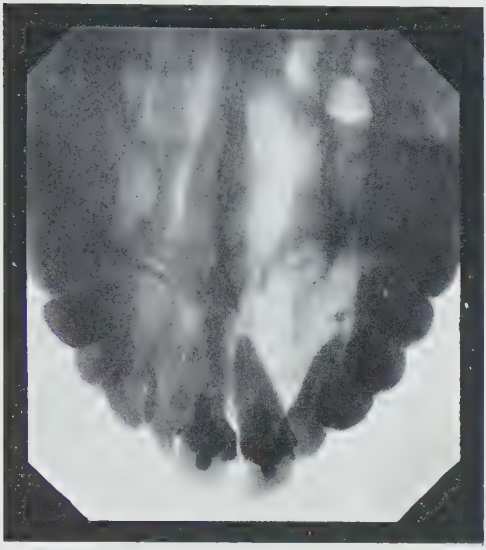


Fig. 321.—Radicular cyst involving maxillary central and lateral incisors, calling for surgical removal of these teeth in order thoroughly to clean out the area.

Fig. 322.—Radicular cyst of the ramus of the mandible.

The cystic content consists of a "serous, slightly mucous fluid." Fat is always present; cholesterin not as often as in the case of root cysts, however, more frequently than is generally

assumed. A purulent or filthy content is due to an external infection, caused by surgical measures (puncture, incision). Infection of the cystic content can also be brought about through adjacent granulomas. On account of their location and size, follicular cysts are frequently wrongly diagnosed. Through perforation of the antrum of Highmore or the nose they are sometimes erroneously diagnosed as empyema of the antrum,

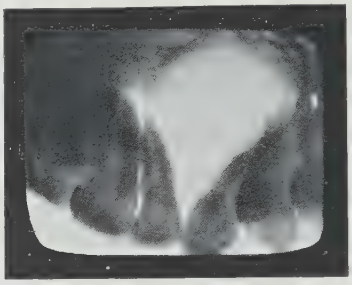


Fig. 323.

Fig. 324.

Fig. 325.

Figs. 323-325. Conservative treatment of radicular cyst. Root-canal therapy should be instituted in teeth giving negative vitality test. Area should then be opened and thoroughly curetted without disturbing the teeth.

especially if the cystic content contains pus. Otherwise complications are only rarely observed.

Differential diagnosis of cysts and malignant growths generally is not difficult. True malignant tumors, sarcomas and carcinomas, grow substantially faster than follicular cysts. They have an irregular, humpy structure which mostly has an ulcerated surface, in contrast to the smooth, sharp-edged surface of cysts. Swelling of regional lymph glands always occurs, as

does also cachexia in the advanced stage of the disease. In connection with cysts, lymph gland affections are seldom, and cachexia is never met with. In contrast to cysts, malignant tumors do not confine themselves to their mother-tissues, but involve the adjacent tissues also. In spite of these distinguishing features, cases have been reported where the diagnosis seemed dubious. A good radiogram and possibly a test-puncture in most cases will suffice to make a correct diagnosis possible. Of the benign true tumors, those proceeding from the enamel organ and the multilocular cystomas deserve consideration.

Here also the x-ray will prove the deciding factor. The x-ray shadow of a follicular cyst shows no structure of any kind and generally stands out in sharp relief from the healthy bone, while in the x-ray shadows of tumors proceeding from the enamel organ and from multilocular cysts, a honeycombed structure is discernible.

Greater diagnostic difficulties are sometimes met in the case of root cysts, which frequently are of extraordinary size. In this instance the location of the cyst in the alveolar process and the presence of a pulpless tooth serve as indicators of their genesis.

Examination with an electric current of the living pulp of such teeth whose roots project into the cyst, or, should they by chance have lost their pulp, an x-ray picture which clearly reveals the cystic tooth, will make a definite diagnosis possible.

An abscess, particularly one of the palate, can present difficulties in diagnosis. Pain, duration of development, location, result of a test-puncture, an x-ray,—all are factors which materially aid in arriving at a diagnosis.

Cysts which project into the antrum frequently, as already pointed out, give rise to confusion; clinical course, test-irrigations, illuminations, or x-ray must be resorted to in order to establish a diagnosis.

The prognosis for follicular cysts is favorable. Follicular cysts confine themselves to their parent-tissue, the jaw, and do not encroach upon adjacent areas. Complications which may occur during the formation of a follicular cyst are not of such a nature as greatly to influence the prognosis. In earlier treat-

ment-methods of follicular cysts, where invariably a resection of the respective jaw was performed, the prognosis was naturally much more unfavorable, since a partial mutilation of the patient resulted.

Through modern methods of treatment, the prognosis is favorable. On the average, the cysts heal up completely in from four to eight weeks.

During the last few years the methods of treatment have undergone frequent changes. First of all, an attempt was made to treat small cysts through puncture, followed by an injection of a corroding fluid, or else simply to resort to an incision. For larger cysts resection only was indicated. The result of a puncture or an incision was that the edges of the wound quickly closed up and that the cyst, therefore, began to fill anew. When it was finally determined that the affection was of a mild nature, resection was dispensed with. Perona then advocated the absolute rooting-out of the cystic sac.

The best treatment for dentigerous and radicular cysts is the removal of the cause and the enucleation of the entire cystic membrane. For convenience in operation these cysts may be divided into three distinct groups.

First, where upon digital palpation there is no evidence of fluctuation, and the only evidence that we have of cystic formation is determined by means of a radiogram. In this particular form of cyst, an incision should be made through the mucous membrane and periosteum directly to the bone. The mucoperiosteal flap is elevated, the hard overlying bone is also removed by the aid of chisels, the cyst is enucleated, all sharp edges of bone are made smooth and the lips of the wound, excepting the anterior portion which is permitted to remain open for dressing or drainage, is sutured.

The second type of cyst is where we have distinct fluctuation upon digital palpation, where the bone has been completely destroyed, and where the cystic membrane is directly beneath the mucous membrane.

In this particular type of cyst, incision is made through the mucous membrane (care should be taken not to cut the entire structure), the mucous membrane is completely dissected away, and the cyst is removed. The wound is then sutured, the ante-

rior portion being permitted to remain open for dressing or for drainage.

In the third type of cyst there is evidence of fluctuation upon digital palpation, but not as distinct as in the second form, be-

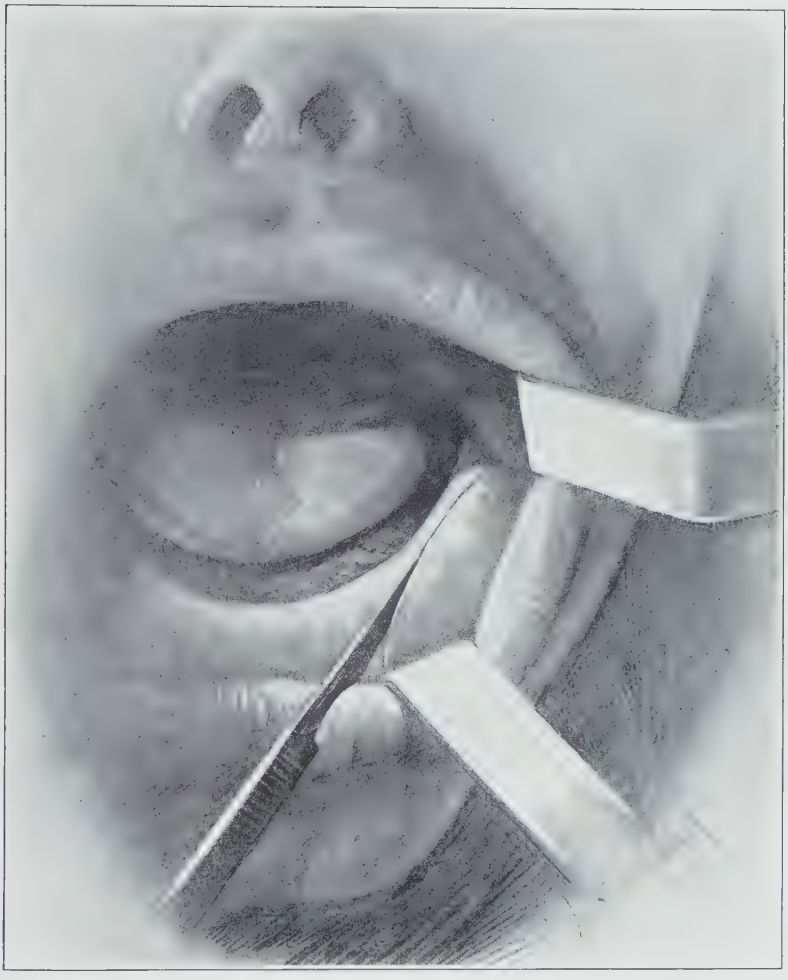


Fig. 326.—Nature of incision for follicular or radicular cyst-type where there is evidence upon digital palpation of an eggshell-like consistency of bone.

cause the bone is not completely destroyed. However, the bone is considerably thinned and assumes an eggshell-like consistency. Here, when we compress, the classical wave-like motion of fluctuation is not present, but upon releasing pressure it immediately assumes its original position, somewhat like a spring.

When this type of cyst presents, whether radicular or follicular, an incision just through the mucous membrane should be made, and the flap removed, whereupon the overlying bone can be easily removed by the aid of Ronguer or hemostatic

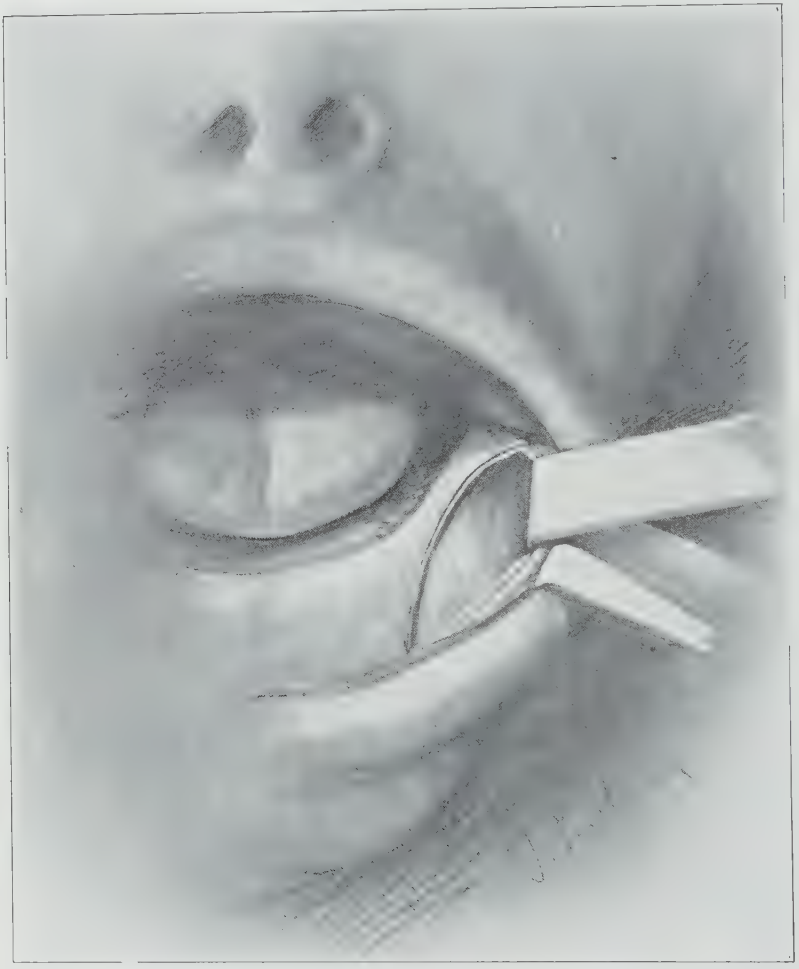


Fig. 327.—Overlying bone removed from the entire extent of cystic cavity.

forceps. A suitable portion of it should be removed to give us a clear view of the entire cystic membrane, the cyst enucleated, the wound sutured, and preferably, the anterior portion permitted to remain open for dressing or for drainage.

The usual postoperative treatment, irrigation of the wound until closed, should be continued.

Dental root or radicular cysts, occurring in the anterior por-

Fig. 328.—Showing the eggshell-like consistency of bone which can readily be removed by the aid of hemostats.

tion of the mouth, as for example over the apices of incisors, canines or bicuspids, may be treated by conservative surgery. The determining factor is the condition of the bone from the gingival margin to the apex. When this portion of bone is in-

tact, root canal therapy should be instituted first, and the area subsequently opened and the cysts enucleated.

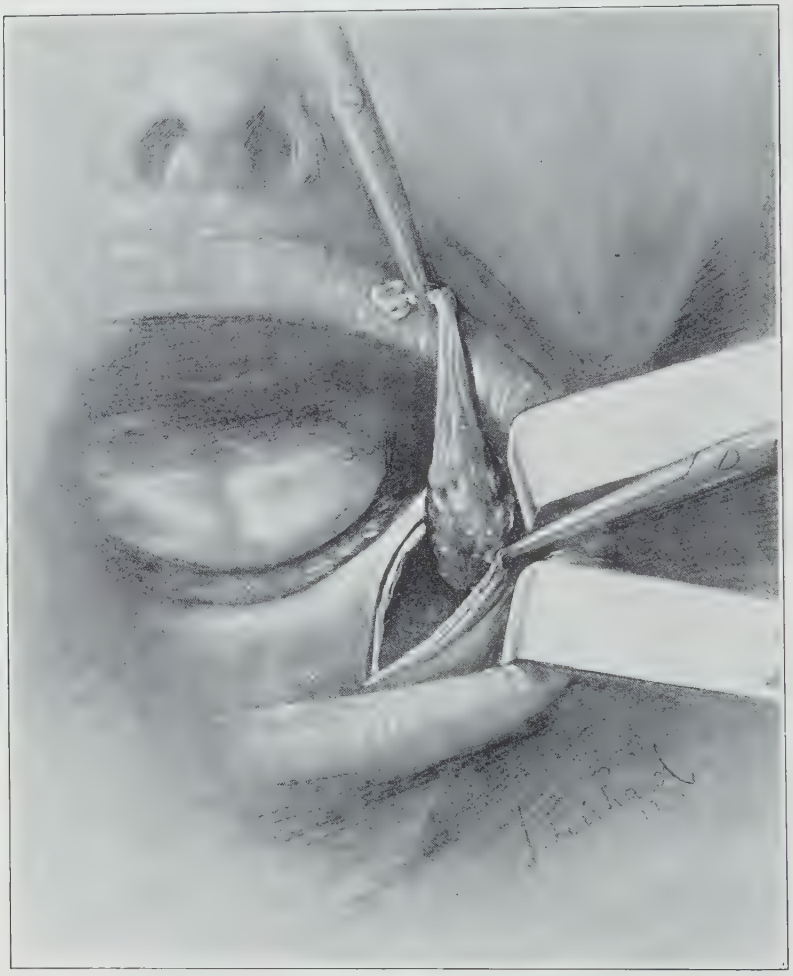


Fig. 329.—Showing enucleation of the cystic bag *en masse*.

Measures for the Prevention of Postoperative Pain

Postoperative pain may be (1) avoidable; (2) unavoidable.

1. The operator is in a position to avoid postoperative pain which will arise as the result of faulty technic. Necessary precautions on the part of the operator begin with the very first step in the operation and must not be omitted until the last de-

tail of the operation is concluded. Surgical cleanliness; properly prepared, sterile, and isotonic anesthetic solution, when local anesthesia is administered; proper selection of type and site of injection; slowness of injection; and last, but not least important, gentleness and delicacy in operating, contribute to the elimination or to the mitigation of postoperative pain.

In judging the importance of postoperative pain, the operator must bear in mind that in the hypersensitive patient, what would ordinarily be considered trifling discomfort is magnified into excruciating pain.

2. Unavoidable postoperative pain is largely due to trauma contingent upon the operation.

Remedial agents for postoperative pain should be available for prompt use. Sprinkling of pure novocaine powder, or parathesin powder into the wound renders immediate relief, which is usually prolonged.

Of late I have applied a dressing of pariphor paste as supplied in the pariphor collapsule. Each collapsule contains 0.15 gm. parathesin and 0.02 gm. rivanol in a fatty paste. Parathesin on account of its being practically insoluble affords continuous relief. Rivanol is a very efficacious nonirritating germicide of the acridine series; thus, in this combination, the operator has available simultaneous anesthetic and antiseptic effects. The collapsule container provides the operator with a practical device which, because of its long, curved neck, will admit of direct application of the pariphor paste into the socket with but few simple preliminaries; namely, (1) cutting off the end of the rigid tip of the collapsule, and (2) by finger pressure on the bulb, expressing the paste directly into the desired area. I have routinely used this form of medication with very satisfactory results.

Pyramidon is a useful analgesic for internal medication to combat both postoperative pain and discomfort. The patient is advised to take one 5-grain tablet of pyramidon immediately after the operation and this dose may be repeated after two or three hours, if necessary. Children should be given a 1½-grain pyramidon tablet dissolved in a little water.

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